THE

FOUNDRY TRADE JOURNAL

WITH WHICH IS INCORPORATED

THE IRON AND STEEL TRADES JOURNAL

Vol. 65 Thursday, August 21, 1941 N . 1305

PUBLISHED WEEKLY

Subscription Terms (Home and Overseas): 21s. per annum. All Subscriptions are payable in advance.

THE FOUNDRY TRADE JOURNAL
49, Wellington Street, London, W.C.2.
WARTIME ADDRESS
to which all communications should be sent until further notice:—
3, Amersham Road, HIGH WYCOMBE, Bucks.
Telegraphic Address: "Zacatecas, High Wycombe."
Telephone: HIGH WYCOMBE 1792 (3 lines).

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Contents

	PAGE
Special-Duty Cast Irons	119
Copper Supplies	120
Correspondence	120
Random Shots	120
Reports on Special-Duty Cast Irons	121
American Synthetic Sand Practice	123
Intergranular Corrosion	126
Principles and Practice of Core-Blowing	127
Piecework and Production	130
The Week's News in Brief	134
Trade Talk	134
Personal	134
Obituary	134
New Companies	134
Reports and Dividends	134
Iron-Foundry Workers	134
Raw Material Markets	136

Special-Duty Cast Irons

The second report recently issued by the Institution of Mechanical Engineers, to which reference was made in our penultimate issue, both prepared by the Committee's Reporter, Mr. J. G. Pearce, is on the well-named special-duty cast irons. These refer to irons of austenitic and martensitic structure as distinct from the high-duty cast irons of pearlitic structure used for their mechanical strength. The Report consists of a survey of their properties as disclosed in authoritative technical literature. Both types are of comparatively recent development, the first of the austenitic irons being Nomag, evolved by the late Mr. S. E. Dawson, followed by Ni-resist and Nicrosilal. The martensitic irons are of still more recent origin. Some metallurgists consider that these types of cast iron form the most significant and interesting development of recent times in the metallurgy of cast iron.

The Report is prefaced by a discussion of the various types of cast iron, so that the relation of the special-duty irons to each other and to the ordinary irons can be readily appreciated. The consideration given leads to a classification of cast irons, which promises to be of general use and value. Briefly, irons are grouped into three classes, according to the absence or presence of graphite, and according to whether the graphite is flake or temper carbon. The irons are also grouped according to their structure, of which six are differentiated, showing marked differences in Brinell hardness. These are ferritic, mixed ferritic-pearlitic, pearlitic, austenitic, martensitic and cementitic. Although doubtless any graphite type is theoretically possible with any structural matrix, in practice the number of groups is eight, of which the major pearlitic group can be divided into six sub-groups according to mechanical properties.

The object of the Report in presenting a survey of the properties of the austenitic and martensitic cast irons is to give engineers information needed in design so that these irons may be used to the fullest extent justified by their special properties. Compared with the ordinary cast irons these properties are of a very striking character. The austenitic irons are strong but much more ductile than the ordinary irons and have an elongation of 2 or 3 per cent. in tension and deflections in transverse reaching five or six times that obtained from ordinary irons. They are very soft and yet are highly resistant to wear and abrasion. They are much more resistant to shock than ordinary irons; and are both corrosion and heat-resistant. They are non-magnetic; possess a high electrical resistance; a greater thermal expansion, and a lesser thermal conductivity than the ordinary cast iron. Moreover, they are readily welded, and are not susceptible to ordinary heat treatment of the type used on high-duty cast irons, although a low-temperature anneal is sometimes an advantage. They can be cast white and can then be softened by a short anneal at about 950 deg. C. Austenitic irons can be cast in very thin sections, but if they should inadvertently become white, the same annealing treatment can be applied. Their high expansion on heating means a high shrinkage on cooling, for which allowance has to be made in casting, and need rather higher melting and pouring temperatures and larger gates and risers. Apart from these points, the founding of austenitic irons presents no special difficulties. The applications of these irons in engineering practice given in the Report make an impressive list, and it is noteworthy that the large majority of the references from which the data in the Report have been drawn are to British workers.

The martensitic irons have had an even more recent application in engineering than the austenitic irons, and two kinds are distinguished, both having grains martensitic instead of pearlitic in character, while the one has a grey and the other a white eutectic filling around the primary grains. The latter is of course the type most used in practice either as Ni-hard or under some other trade name. The distinguishing feature of this type is its resistance to wear, erosion and abrasion, and a number of applications are given. There is no doubt that both engineers and founders will find these two Reports of great value and interest.

The list of facts known about both types of iron is impressive testimony to the knowledge gained about them since their discovery. There is room for variation in composition to emphasise one property or another according to the service required, and it must not be supposed that all austenitic irons necessarily have all these properties in the highest degree. They are in fact possessed by those irons known by their brand names.

The term "special-duty" may well be used to cover all those irons made for their special properties, that is, properties other than mechanical strength; for example, the high-silicon and high-chromium irons. The same applies to irons surface-treated or cemented to resist heat or wear, in which the nitrogen-hardened irons might be placed.

Copper Supplies

BY "ONLOOKER."

While it may be doubted whether the system of control in copper instituted in the United States goes to the heart of things in quite the fashion it does in this country, there has been instituted, nevertheless, a scheme of priorities which must go a long way towards ensuring that, so far as the war effort is concerned, first things really are put first. There can be no doubt that the rate of consumption in the States has been advancing steadily. Something like twelve months ago, to be exact in September, 1940, deliveries of refined copper to consumers fell short of 100,000 tons. Six months later, in March of this year, the corresponding figure was 134,333 tons, but it should be noted that in this was included an addition of over 31,000 tons, consisting of brands imported from Latin America. The July figure, which is the most recent available, amounted in total to 143,089 tons, of which some 32,500 tons came from foreign sources, so that the industry in the States is heading for the 150,000-ton mark. Not so satisfactory is the evidence that stocks are being drawn upon, for the July statistics show that there was a reduction from 98,164 tons at June 30 to 74,384 tons of refined at July 31. The domestic production of the United States keeps below 90,000 tons, but this, with the contribution from Chile, provided that shipping space can be found, creates an impressive total which ought to give ample cover for production if commercial uses, or some of them at any rate, are pushed into the background.

It has been contended that a higher price would bring a bigger domestic production, but it does not seem as if the authorities set much store by this, for a maximum of 12 cents has now been officially announced, so that all rumours relating to a possible 14-cent level can be dismissed, at any rate for the present. A few weeks ago a step towards the full control of copper was taken when dealing in copper futures on the Commodity Exchange were suspended and arrangements made for the liquidation of outstanding positions. It will be remembered that in this country action along parallel lines was instituted immediately upon the outbreak of war in September, 1939, and quite a considerable quantity of standard copper was eventually taken over by the Control and passed into consumption. The imports of South American copper are being operated by the Metals Reserve Company in order that this tonnage may be kept under proper control and prevented from passing into channels of consumption outside the war effort, and in this way, too, the difficulty of the 4-cent import duty levied on all imports of foreign copper can be overcome. Since South America's production, according to the American Bureau of Metal Statistics, was about 435,000 short tons in 1940, it is evident that the U.S. second string is fairly long and strong, particularly as the 1940 figure is likely to be surpassed during the present year.

Since Russia's production of copper is not much over 100,000 tons, it is obvious that Britain and the United States in the terms of the promises given by the leaders of the democracies will be obliged to come to the help of our ally as far as non-ferrous metals are concerned. Whether such assistance will be provided in the shape of semis, finished products, or raw materials matters little, for the wherewithal must be withdrawn from the common pool. Fortunately, this is very deep and wide, for the Empire resources in copper are enormous, as the course of production in this country since the outbreak of war has shown, and when to this tonnage is added the production of the

(*Continued at foot of next column.*)

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

To the Editor of the FOUNDRY TRADE JOURNAL.

Valves for Blacking Mixing Machines

SIR,—I have studied with much interest the Paper on "Mould and Core Washes," by Mr. Wm. Y. Buchanan, which appears in July 31 issue of the FOUNDRY TRADE JOURNAL, and am generally in agreement with what Mr. Buchanan has to say upon this most important subject.

It is, however, surprising in these days to learn that a process such as this should be so severely hampered by the failure in service of the valves used for controlling the fluid under treatment. The humble valve thus comes into the limelight as an item of much greater importance than is generally realised. Besides the "regular appearance of invoices for replacements," the fact cannot be lost sight of that the leakage attributed to the types of valve used would result in the process of mechanical mixing being looked upon with disfavour.

In the hope that it may be of assistance, I would like to bring to the notice of Mr. Wm. Y. Buchanan a type of valve which is apparently new to him. I refer to a locally made diaphragm valve, of which I have had sufficient experience to know that this valve is eminently suitable for the duty discussed in the Paper. The enclosed leaflet, acquired from one of this company's representatives at the time of our placing an order for some of their valves, shows the principle of operation of the valve. I do not propose to enlarge upon the information contained in this leaflet, as this is quite sufficient to bring home to the reader the advantages of this type of valve over the more conventional types touched upon in the Paper, chief of which is that the valve may be closed down on to any small solids (which may have become trapped in the valve) without impairing its closure tightness.

If these few remarks prove of interest to Mr. Buchanan I shall have the satisfaction of knowing that I have been able to lend a helping hand by passing on, as a result of my own experience, the "tip" he may have been waiting for.—Yours, etc.,

G. W. CAPWELL
(Foundry Foreman).

547, Chepstow Road, Newport, Mon.
August 14, 1941.

[The leaflet referred to in the above letter has been sent to Mr. Buchanan.—EDITOR.]

Notes from the Branches

Loodon.—A meeting is to be held at 6.30 p.m. on September 1 at the National Liberal Club, Whitehall Place, S.W.1, when Mr. J. H. Maybury, B.A., is dealing with the important subject of the making of light alloy die casting, based on his experience as a manufacturer. Non-members are invited to attend either through the introduction of a member or by an invitation card which will be sent on application to the honorary secretary, 3, Amersham Road, High Wycombe, Bucks.

(*Continued from previous column*)

Continent of America, then we are within striking distance of the grand total, for the fact of the matter is that between them the British Empire and the United States control practically the whole of the world's copper supplies. What Germany's position is to-day must be conjecture, but her supplies must surely be running very low.

Random Shots

It is reported that Mr. Ford has produced a car made almost exclusively of plastics. That being so, it is to be presumed that the plastics of to-day are not what they used to be. "Marksman" once possessed a beautiful set of white plastic bathroom fittings which on exposure to the dampness of the bathroom atmosphere just cockled up like a piece of frizzled bacon rind. It is still the tendency amongst children, thank goodness, not to take out their shining new bicycle on a rainy day for fear of getting it rusty, but the days have long since passed when motorists left the car at home and called a taxi when it rained for fear of getting it muddy. Another unpleasant experience with plastics came when (possibly worried over the arrival of an income tax demand note) "Marksman" threw the plastic ashtray in the fire and carefully placed the cigarette end on the polished table. The dense dark fumes which arose to fill the room and the pungent smell which was emitted drove the whole family out of the house for the rest of the day. The memory of that smell would be quite sufficient to produce a peculiar sensation of car sickness even at the sight of a plastic motor car in the future.

* * *

It is said that a certain Aberdonian has been busy during these extra long light evenings learning Braille. He hopes that in the coming winter he will be able to read in bed without a light.

* * *

"Gosh!" said a youngster, wakened in the middle of night by the sound of a 'plane passing rather low overhead, "that aeroplane's got an unpatriotic sound about it!"

* * *

"Is this steak really Kosher?" anxiously inquired Mr. Finckelstein when dining at an unaccustomed restaurant. "Kosher? I should just think it is," replied the proprietor. "Why, it ran at least three seasons for Solly Joel."

* * *

The publicity manager's young daughter burst into the drawing room one Sunday afternoon, after attending Sunday school. "Oh, look, Pop," she cried, producing a picture-collect, "see what they gave me at school to-day. A fine new advert. for heaven."

* * *

"Oh, Daddy," remarked a youngster just at the end of the summer term, "they asked me at school to-day which you wanted me to start on next term; Latin or German."

"And what did you say?"

"Well, I said we hadn't discussed it really, but as far as I'm concerned there isn't much to choose between them. Latin's been a dead language for a long time, and German's as good as dead already."

* * *

A young woman munition trainee was so run down that she was advised to consult the doctor. The combined effort of learning a new job and looking after her home and husband after working hours had proved too much for her. "What I prescribe for you," said the kindly doctor, "is a holiday. You are badly in need of a little sun and air." "Good gracious, Doctor," she cried in horror, "I've got six kids evacuated in the country already."

* * *

The Prince of Wales secretly meets Augusta in mid-Atlantic. A truly romantic tryst!

"MARKSMAN."

Comparative Efficiency of Smelting Processes

Calculations and comparisons of various smelting processes made by A. CARLI in "Metallurgica Italiana" indicate that the blast furnace is one of the most efficient industrial processes in use from both the thermal and chemical standpoints, owing to the complete and economic utilisation of every component of the charge.

Reports on Special-Duty Cast Irons

I—TYPES OF CAST IRON

By J. G. PEARCE, M.Sc., M.I.Mech.E. (Director, British Cast Iron Research Association)

The First Report of the Research Committee of the Institution of Mechanical Engineers on High-Duty Cast Irons for General Engineering Purposes outlined briefly the development both of high-duty cast irons used by engineers for their superior strengths, and special-duty cast irons used mainly on account of other properties. As a consequence of the war, a demand has arisen among engineers and users for further information on special-duty irons, which are being used both as substitutes for other materials in urgent demand and for new applications arising out of the unusual conditions now prevailing. The Committee therefore decided that monographs should be prepared for the purpose of providing engineers and users with information available, and the present reports cover two relatively new types of special-duty cast iron—the austenitic and martensitic irons. To avoid repetition in introductory statements relating to the character of these irons, the two reports are prefaced by a description of the types of cast iron available, which it is hoped may prove generally useful as well as a convenient summary of the relationship of the two types to each other and to the other cast irons in general use.*

AUSTENITIC AND MARTENSITIC SPECIAL-DUTY CAST IRONS

It is an advantage if the properties of particular types of cast iron are prefaced by a statement of the nature of the various types and their relationship to each other, including the ordinary and high-duty irons, used in engineering primarily for their mechanical properties, and also the special-duty irons used on account of other properties. Such a statement becomes in effect a mode of classification, distinguishing the broader types or classes and differentiating the several varieties existing within each class. In view of the widening field of cast-iron metallurgy, great practical convenience results from a scheme of grouping to which branded, processed, and other cast irons may be referred. An ideal classification would accommodate all cast irons, the different types showing differences in kind, and the varieties within each type differences in degree. The scheme indicated below is a first approximation to such an ideal, prepared for the engineering user rather than the maker, and kept as free as possible from metallurgical technicalities.

A strict metallurgical definition of cast iron is to-day sought in terms of structure. Cast irons are alloys of iron and carbon (with or without other elements) which contain eutectic carbide (the characteristic constituent of white cast iron), or eutectic graphite (the characteristic constituent of grey cast iron), or both (as in mottled cast iron), in the structure. They may contain from about 1.0 per cent. to 4.5 per cent. of carbon, and are not usefully wrought at any temperature.

The definition indicates for each case the essential constituent which serves to distinguish cast iron from steel, but the actual structure contains more than one constituent, and no cast iron can consist exclusively of grains of one constituent only. This, however, causes no difficulty in classification if the structural assignment of a cast iron is that of its predominating constituent, which in the main determines its properties. Deliberate variations in composition, manufacture and treatment may be made to suit the varying complexities of service requirements, so that some irons are not typical of, but are rather borderline cases in their structural groups. In the great majority of cases, however, the structural group of a cast iron serves to indicate at once the probable range of properties.

Grouping on Graphite and Matrix Bases

The old visual distinction between pig or cast irons as grey, white, and mottled is no longer valid, although the large bulk of engineering cast irons are grey and machinable, being structurally pearlitic, while white irons are hard and not ordinarily machinable. All cast irons can conveniently be grouped with reference to the presence and form of graphite, and with reference to the structure of the matrix in which the graphite is distributed. So far as the matrix is concerned, six structural groups can be identified, the difference between which are best appreciated from a simplified consideration of the mode of solidification and of the ultimate structure of the metal in the cold.

In an ordinary engineering cast iron in the molten state, the melt is saturated with respect to austenite at the temperature at which solidification begins. Austenite is a non-magnetic form of iron, containing carbon in solution to a maximum of 1.7 per cent. Crystals or primary grains of austenite separate from the melt at about 1,200 deg. C., and, as cooling proceeds, more austenite is deposited and the mother liquor becomes progressively richer in carbon, since the melt contains more than 1.7 per cent. This continues until the mother liquor is saturated with both austenite and carbon and the composition at the appropriate temperature, about 1,180 deg. C., is then that of a eutectic. If the iron is such that it solidifies white, the mother liquor solidifies round the primary grains as a eutectic, a microscopically fine conglomerate of austenite and cementite (iron carbide). In the case of grey iron, the eutectic consists of austenite and graphite solidifying round the primary austenitic grains. While the austenite, both of the primary grains and the eutectic, is able to hold up to 1.7 per cent. carbon in solution at solidification, some of this carbon is rejected as graphite as cooling proceeds, diffusing to the nearest eutectic flakes. At about 760 deg. C. a constitutional change takes place, known as the pearlitic change, and the duplex structure known as pearlite is formed from austenite. When austenitic grains transform to pearlitic grains, a physical mixture of microscopically fine laminations of iron carbide (cementite) and iron (ferrite, or α-iron) is formed, the proportions being such that the carbon combined as carbide is about 0.7 per cent. (0.9 per cent. in pure iron-carbon alloys). A modern cast iron can be made to yield pearlite from both the constituents present on solidification, with graphite in the flake form. If, however, the cooling is very slow, or if graphitising elements like silicon are present in excess, some or all of the carbide of the pearlite may break down to ferrite and graphite, giving a mixed ferrite-pearlite, or a wholly ferritic matrix.

Thus, in the cold state, an engineering grey cast iron may be ferritic, pearlitic, or a mixture of the two, and subsequent thermal treatment can be applied to convert a pearlitic iron to a mixed or wholly ferritic structure. This treatment is frequently used to soften castings, in order to give greater machinability. Such dead-annealing to secure easy machining reduces strength, since it replaces pearlite by softer ferrite. Comparatively slight thermal treatment is also sometimes applied to relieve internal stress, but this does not affect either structure or mechanical properties. Heat-treatment by quenching and tempering, as used for steels, can also be applied, and materially enhances properties through a refinement of the structure.

On the other hand, if the rate of cooling is rapid, or if the amount of graphitising elements present is small, the carbide of the eutectic may remain unchanged, a hard, brittle material which gives in the cold a white iron, which may be used as such, and which is graphite-free.

White irons can also be thermally treated to yield a machinable material, and this is the normal procedure in making malleable cast iron. Castings are cast in the white state and annealed, and under this treatment the graphite takes on the special nodular form known as temper carbon, characteristic of malleable irons. The matrix again may be made ferritic, pearlitic, or a mixture of both, according to the composition and annealing cycle adopted.

Of these constituents, ferrite (sometimes called α-iron) is comparatively soft and ductile; pearlite is stronger, harder, and less ductile; while cementite is very hard and brittle. For practical purposes at ordinary temperatures, the duplex constituent pearlite behaves as a single simple material.

Wide Range of Possible Structures

The range of possible structures, however, is not yet exhausted. As indicated above, in normal grey irons, the austenite (sometimes called γ-iron) is transformed to pearlite at about 760 deg. C. Certain alloy additions to cast iron are known to depress the temperature of this change, and if added in sufficient quantity will reduce it to a temperature below atmospheric, so that the metal remains austenitic in the cold state. Under these conditions austenite is the predominating constituent, with the austenite-graphite eutectic acting as a filling between the grains. "White" austenitic irons, in which the carbide of the eutectic filling remains unchanged, are not normally required, but if any cementite should remain, it can be removed by a short annealing at 950 deg. C. Austenitic irons, since they possess no pearlite change point, do not normally respond to conventional heat-treatment, quenching and tempering. Austenitic irons have been developed within the past fifteen years.

The normal change on cooling from austenite to pearlite, or, if the cooling is sufficiently prolonged, to ferrite, can be so far suppressed that, as indicated above, austenite is retained in the cold state. The effective rate of cooling can also be modified to produce an intermediate result, in which austenite is changed, not to pearlite, but to martensite, a hard substance characterised by an acicular or needle-like structure. It may be regarded as a transformation product of austenite obtained by cooling rapidly enough to prevent the carbon dissolved as iron carbide in the austenite from being thrown out of solution in the normal way. Martensite formation can be promoted by appropriate heat-treatment of cast irons which are pearlitic in the as-cast state. Alternatively, the martensitic form can be produced in the as-cast state, even with the rate of cooling given by a sand mould by alloy additions which have the same effect as a more rapid rate of cooling.

* Proceedings of the Institution of Mechanical Engineers, 1938, vol. 140, p. 133.

Special-Duty Cast Irons—I

These additions retard the rate and lower the temperature at which the austenite decomposes. Both these effects tend to prevent the completeness of the transformation and assist in the retention of martensite.

By appropriate choice of conditions, a normally pearlitic structure can be made wholly martensitic, a mixture of martensite and pearlite or a mixture of martensite and austenite. As martensite is very hard (the possibility of hardening steel being due to its formation), martensitic irons find their principal applications where resistance to wear and abrasion is required. The additional hardness obtained by having the eutectic surrounding the martensite grains in the hard white state is therefore sometimes an advantage. Hence, two grades of hardness are available in the intrinsically hard martensitic irons: that in which the carbide of the eutectic is unchanged, giving a range of Brinell hardness of 550 to 700; and that in which the carbide has broken down to graphite, giving a range of Brinell hardness of 350 to 450, according to composition, section, and rate of abstraction of heat by the mould material. In high-duty irons used for strength, a proportion of martensite in the structure has been found to be advantageous, but these irons belong to the pearlitic class, with a Brinell hardness of about 300 to 350, rather than to the martensitic class, although they reveal an acicular structure.

Six Structural Groups

Six structural groups can therefore be recognised, and to indicate the effect of structure on properties, the range of Brinell hardness for each is given :—

(1) Ferritic	..	110 to 140
(2) Ferritic-pearlitic		140 to 180
(3) Pearlitic	..	180 to 350
(4) Austenitic	..	140 to 160 (160 to 220 with chromium)
(5) Martensitic	Soft	350 to 450
	Hard	550 to 700
(6) Cementitic	..	280 to 550

From the engineer's or user's point of view, the pearlitic group is by far the largest and most important, and includes the bulk of castings made, and this group can with advantage be subdivided on a basis of mechanical properties and in accordance with national specifications.

Brief reference may be made to the effect of phosphorus on structure. It forms iron phosphide, which becomes with part of the iron a microscopically fine conglomerate existing as a eutectic, and solidifying after the remainder of the metal. This is visible in the microstructure, and is relatively hard and brittle. It is not subject to change by thermal treatment, and in irons of appropriate compositions it takes the form of a network or honeycomb structure.

CLASSIFICATION OF CAST IRONS

Graphite

Cast irons can thus be primarily classified as graphite-free, as in the white cast irons, in which all the carbon is in the combined form, or graphite-bearing, in which the graphite is in one of the following forms, being chemically and physically the same in all of them.

(1) Flake graphite, characteristic of grey pig and cast irons, and showing great variety in size, shape and distribution.

(2) Temper carbon nodules, characteristic of malleable cast iron.

(3) Very finely divided flakes, regularly distributed and variously named, but sometimes called "super-cooled" graphite. In commercially made structures, graphite is seldom found existing exclusively in this last form, further consideration of which is therefore omitted for the present purpose.

Although a number of attempts have been made to classify the flake graphite forms in grey iron, the examination of thousands of samples in the British Cast Iron Research Association's laboratories has failed to offer any basis for such classification, or to suggest a relationship with properties going beyond general statements. Graphite quantity and distribution, however, exercise a profound influence on properties. With rare exceptions, the annealing of solid white iron, as practised in the malleable annealing process, is the only way at present known of producing temper carbon, and some of the special properties of malleable cast iron must be ascribed to this graphitic form. The properties of the white cast irons are also determined mainly by the combined form of the graphite, as cementite. Hence this grouping corresponds with profound differences in properties, and the influence of the matrix can now be considered. The First Report gives some illustrations of varieties in type and size of graphite.

Ferritic Irons

In the normal as-cast condition, no ordinary engineering cast irons are wholly ferritic, as such irons require to have higher contents of graphitising elements, such as silicon, than is desirable for normal use. Such irons, however, are made for heat- and acid-resisting purposes and these are, or may be regarded as, wholly ferritic. Irons high in chromium content also have a ferritic matrix. The hardness and machinability are considerably modified by the special composition of these irons. As mentioned above, engineering cast irons can be rendered wholly ferritic by appropriate annealing, either of pearlitic or of white (cementitic) irons used for malleable castings.

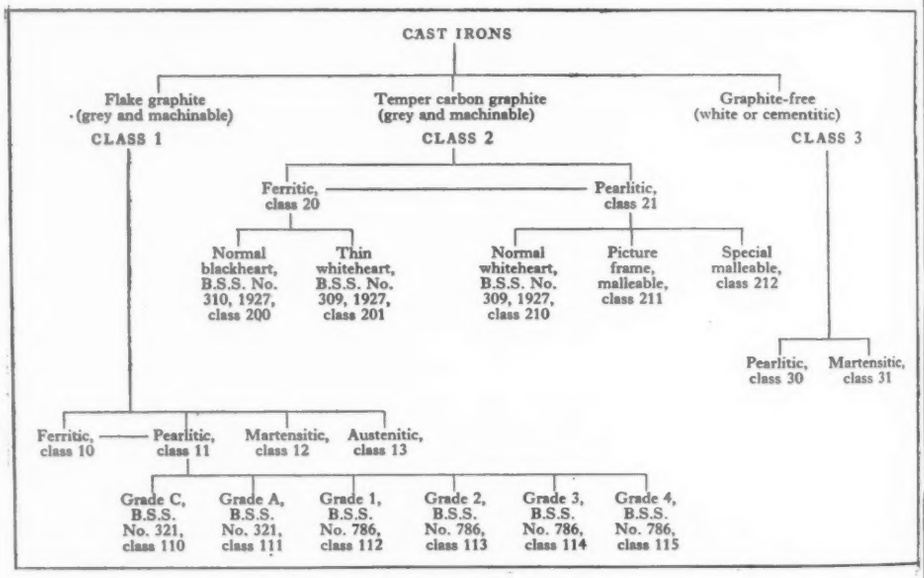
CAST IRONS
Flake graphite (grey and machinable)
CLASS 1
Temper carbon graphite (grey and machinable)
CLASS 2
Graphite-free (white or cementitic)
CLASS 3
Ferritic, class 20
Pearlitic, class 21
Normal blackheart, B.S.S. No. 310, 1927, class 200
Thin whiteheart, B.S.S. No. 309, 1927, class 201
Normal whiteheart, B.S.S. No. 309, 1927, class 210
Picture frame, malleable, class 211
Special malleable, class 212
Pearlitic, class 30
Martensitic, class 31
Ferritic, class 10
Pearlitic, class 11
Martensitic, class 12
Austenitic, class 13
Grade C, B.S.S. No. 321, class 110
Grade A, B.S.S. No. 321, class 111
Grade 1, B.S.S. No. 786, class 112
Grade 2, B.S.S. No. 786, class 113
Grade 3, B.S.S. No. 786, class 114
Grade 4, B.S.S. No. 786, class 115

FIG. 1.—CLASSIFICATION OF CAST IRONS.

Ferritic-Pearlitic Irons

The large majority of common cast irons in the as-cast condition have a mixed ferrite-pearlite structure with flake graphite and, in general, have properties intermediate between those of the ferritic and pearlitic irons, harder and stronger than the former, less hard and strong than the latter. The malleable annealing of white irons can be arranged to give a mixed ferrite-pearlite structure with temper carbon.

Pearlitic Irons

It is generally acknowledged that the best structural cast irons should be all-pearlitic, with flake graphite. While the pearlite usually takes the lamellar form described above, some variation in degree of refinement of the lamellæ occurs, according to local conditions, and sometimes the carbide is so finely divided as to justify special designations—sorbitic or troostitic. By heat-treatment, the carbide can be made to assume the form of spherical islands in ferrite, and the metal is then said to be spheroidised.

If a cast-iron, all-pearlitic with about 0.7 per cent. of carbon in the combined form, contains less than this percentage of combined carbon, some ferrite is present; if more, some free cementite or carbide. The extent to which a cast iron can be hardened by the presence of carbide over and above that required for pearlite formation, without sacrificing machinability, is limited, but the combined carbon can be raised to 1.1 per cent. or more without yielding an unduly hard or unmachinable material, and with improved mechanical properties. Pearlite remains the dominating constituent. Such irons can also be spheroidised. Malleable annealing of white cast iron can be arranged to give an all-pearlitic structure with temper carbon. Pearlitic irons are harder and stronger than ferritic or ferritic-pearlitic irons.

Austenitic Irons

These, which have been developed during the last fifteen years, are essentially special-duty irons. They have special properties, being relatively soft and ductile, non-magnetic, of high electrical resistance, high thermal expansion and low thermal conductivity. They offer high resistance to wear, erosion, corrosion and heat. These properties are possessed in the highest degree by certain types only, other types having them to a lesser degree. Austenitic irons can be softened by annealing, but do not respond to ordinary heat-treatment (quenching and tempering). Austenitic irons under the microscope show graphite in a structurally featureless background of austenite unless some free carbide is present, such as chromium carbide.

Martensitic Irons

These again are essentially special-duty irons, used mainly for resistance to wear and abrasion, and, as indicated above, two grades of hardness are available, according to whether the eutectic surrounding the martensitic grains is white or grey.

Cementitic Irons

White or cementitic irons are made and used in the state in which all the carbon exists in the combined form. In certain applications, of which ploughshares and chilled rolls are familiar

(*Concluded on page* 126.)

American Synthetic Sand Practice

DISCUSSION AT MANCHESTER CONFERENCE OF Mr. NORMAN J. DUNBECK'S PAPER*

A keen discussion, reported at length below, was evoked by the American Foundrymen's Association Exchange Paper by Mr. Norman J. Dunbeck on the subject of American synthetic sand practice, which was submitted on his behalf to the recent Manchester Conference of the Institute of British Foundrymen by Mr. J. J. Sheehan. Owing to the obvious absence of the author, Mr. Sheehan acted as his very able deputy and replied to the contributions made to the discussion.

MR. J. J. SHEEHAN, B.Sc., A.R.C.Sc.I., introducing the Paper for general discussion, said he appreciated the honour of presenting Mr. Dunbeck's Paper, which was of a very interesting character. Moreover, at present the subject matter is of particular importance to British industry, as the general principles outlined are in agreement with the best British practice; the consideration and discussion of such Papers as this should help to make the best practice the general practice.

The remarks on the selection of the base sand are in agreement with his own Paper, "Core Shop Control," presented to the International Foundry Congress held in London in 1939, particularly that section dealing with such defects as buckle and scab. The inclusion of a definite proportion of fines is recommended and the avoidance of the perfectly round uniform grain, once popular in text books, is stressed. Text-book misconceptions have a long life and a tendency to reproduce themselves by reference in subsequent publications. Papers like the present help to inter them.

In compounding a synthetic sand Mr. Dunbeck looks for only three properties in the base sand: Grain size, permeability, and expansion. It is necessary, however, to consider another important property: refractoriness.

Bond Clay

Under this heading much of interest is presented; it is obvious that Mr. Dunbeck is an expert in this section of the subject. Much work is being done in this country at present on identical lines to those outlined in the present Paper. In this connection mention must be made of the following Papers:—

"Fulbond as an Alternative Material to Bentonite for the Bonding of Moulding Sands for Greensand Castings," by Dr. W. J. Rees.

"Trial Mixtures of Colbond," by Mr. T. R. Walker, M.A.

"Practical Trials of Fulbond No. 2," by Dr. R. J. Sarjant.

"Fuller's Earth for Green Sand," by Mr. D. A. Oliver.

The above-mentioned Papers have not yet been published, but permission has been obtained to quote from them should occasion arise in discussion. Particular attention should be given to the following remarks under the sub-heading "Kaolinite Clays": "This is the most widely-used type of bond clay in the United States" and "They are also the lowest in cost and have the highest durability." Illite clays of British origin have not been investigated here, and some attention might profitably be given to them.

Montmorillonite Clays

A bonding material of this type produced in Britain—used alone within the limits of its low sintering point or in combinations with other more refractory clays on the lines indicated by Mr. Dunbeck for a greater variety of purposes—is receiving considerable attention and promises to be of considerable assistance to the industry.

This subject of the combination of clays is the most important recent development in American practice. The examples of such combinations given in this Paper indicate such possibilities here, and are a decided stimulus to intensive work in that direction.

Method of Application

Under this heading Mr. Dunbeck is so common sensed and clear that there is little to remark upon. In practice the method adopted is dependent upon the equipment available more than any other consideration.

Testing and Control

A most important remark under the above heading is "All materials must be entirely dry" when testing the comparative value of clays. Paragraph (3) in this section says: "Clays of the same type should be tested at exactly the same moisture content." The following addition to that remark would be of assistance, *clays of different types should not*. Clays of different types develop their best-tempered condition with different amounts of water. This is indicated by Mr. Dunbeck in Table I. It is therefore misleading to compare the relative values of various types of clay at a moisture content suitable only to a particular one.

Sands

Under the above sub-heading in paragraph (2) Mr. Dunbeck states:—"Some types of clays yield much higher permeability than others, even when present in equal quantity, and although the strength of one may be far higher than the strength of the second." For the words "and although" should be substituted the one word "because."

Some types of clays yield much higher permeability than others, because the conditions of the permeability determination are such that, with three blows of the standard rammer, a stronger sand will be less compacted in the test-piece than a weaker sand, other conditions of the sands being similar.

The advantages and disadvantages of naturally-bonded sands and synthetically-bonded sands have been written about and discussed at length in many Papers. The many points considered are well summarised in this Paper. Altogether Mr. Dunbeck has provided a very stimulating Paper.

Availability of Type of Bentonite

MR. F. J. COOK (Past-President) inquired which of the two bentonites referred to in the Paper was usually imported into this country. According to Table V, it was possible to get 25 per cent. of bentonite and 75 per cent. of clay to a very high compression and strength and with suitable permeability. What appeared to be most remarkable was the hot strength obtainable with such a mixture. If it were possible to use 75 per cent. of clay which could be obtained locally, and only import 25 per cent. of bentonite, it was a proposition which would be very attractive to every foundryman in this country at the present time, when shipping space so much required to be conserved. The two bentonites appeared to be outstanding in their difference of characteristics.

Milling Difficulties

MR. J. H. COOPER (Darlington) thought that a good deal of synthetic sand was not reaching the requisite standard. Difficulties accruing in regard to the use of synthetic sands were very often side-tracked from other considerations. Recently it had been found that, when mixing a synthetic sand, more fresh sand had to be used than when using a natural sand containing a reasonable amount of bond. Synthetic sand enthusiasts said: "You must use a certain proportion of this and a certain proportion of that." Another innovation was that many bonding materials were added either in the form of a wash or to a heap of sand, but this application was carried out in a very careless manner. The consequence was that a synthetic sand was not really of the advantage it could be if more care was taken in application. In some mills the rollers were held up by springs, and there was an adherence of bentonite, Colbond or other materials to the mill pan.

He was not quite convinced as to whether any means had been discovered to prevent such accumulations of clay sticking not only to the side of the pan, but also to the scrapers and the side of the rollers. It would be very interesting to learn if Mr. Sheehan could give any information upon the subject, and it would also be of interest to the subject if he could explain what type of mill roller he preferred; whether he would use the plain or the grooved type. Also, was the mill cleaned systematically, say daily, and not merely when there was trouble with scabs and the like on the castings?

It was found that the amount of burnt sand which adhered to the casting amounted to 12½ per cent. A British sand naturally bonded, free from admixtures, after milling and passing through the mixers, required only the addition of 12½ per cent. of new sand for the maintenance of standard. Would Mr. Sheehan say whether this 12½ per cent. addition brought about excessive silt content in the sand system?

Identification of Bentonite Types

MR. SHEEHAN said that in this country the bentonite normally available was of the Western type. The Southern type had been introduced here recently under a trade name, but it could be readily identified by its property of a comparatively low dry-strength to green-strength ratio. Southern bentonite was a very valuable material.

With regard to Table V, Mr. Cook had remarked upon the hot strength of combinations of bond clays. This particular fact was new to him also; it was the first time he had seen any mention of it, and he did not know any explanation for it. Frankly, to suggest that it might be that the mixture of these two clays had a fusion point that made a glass between the grains giving a very high strength at that temperature, might be a possible explanation. The explanation, however, was not important. What was important was the fact. The combination of clays, either imported or domestic, made for more accurate control.

Superiority of Synthetic Sands

These remarks might be considered also by Mr. Cooper. Synthetic sand appeared to bear no relation in value to naturally-bonded sand. He could not understand Mr. Cooper even advocating naturally-bonded sands; because there was under control every property for an ideal moulding sand once a synthetic sand was established. There was a selection of the base grain; there was the necessary refractoriness; there was fineness if a good finish was required, and with the selection of the various bond clays which were now becoming available, all the properties could be obtained which were indicated in Mr. Dunbeck's Paper.

* Foundry Trade Journal, July 17, 1941, pp. 37–41, and July 24, 1941, pp. 61–64.

American Synthetic Sand Practice

Overcoming Sand Mixing Difficulties

Most certainly attention must be paid to the manner of mixing synthetic sand. In the case of anyone who was not familiar with sand-testing equipment, a very little thing might cause a great deal of harm. The process, however, was so simple that once the sand-testing equipment was understood, the difficulties bore no relation to those associated with the mixing of a naturally-bonded sand.

He would give as an illustration the case of a partially-mechanised steel foundry where two mills of the Simpson type of mixer were used. When this foundry used naturally-bonded sand it required those two mills to work full time—in order to mix sufficient sand for the production of 20 tons of steel castings per week. Then synthetic sand was introduced, and as a result one mill was continuously idle, while the other mill was supplying enough synthetic sand for 40 tons of steel castings per week. This was an indication of the value of synthetic sands as related to time-saving potentialities, for the elimination of one mill and the doubling of output was very significant.

The adherence of the bonding material to the mill parts was due to wrong practice, *viz.*, adding the powder to a wet sand. The powder immediately took up moisture, became sticky, and made distribution difficult. It was necessary when mixing a synthetic sand to add the powder to the dry sand and allow a period of time for dry mixing. Then add water, and there would be no difficulty whatsoever in regard to sticking to the blades or to the bottom of the pan.

As a matter of interest, he had very little predilection regarding the type of sand mill. The mixing of a synthetic sand was so simple a matter that most types could operate. The mill he used was of the continuous type, and he did not think it could function properly if employed upon a heavily-bonded natural-sand, necessitating the breaking up of clay lumps. It worked very easily with synthetic sand, and he had seen it used extensively in this country. In no foundry in this country had he seen the addition of clays carried out by the slurry method, although he could not see why it should not prove to be an excellent method of adding clay. It did introduce another item for consideration, however, in that it was adding clay and water, and perhaps the water would not be under as accurate control as if the clay powder and water were added separately.

MR. F. A. HARPER said that Mr. Cook had emphasised the conservation of shipping space. At the same time, Mr. Sheehan had asked for the discussion of any other bonding materials which could be cited as being available. Perhaps he might be forgiven for pointing out that there was a proprietary article made from rich materials in Britain, and which was now on the market.

A Definition Sought

MR. C. H. KAIN wished to thank Mr. Sheehan for his able presentation of what was perhaps the best Paper they had had before the Institute of British Foundrymen for a very long time. He was particularly impressed with the paragraph in which Mr. Dunbeck pointed out he had read occasional references in the British technical Press to the effect that synthetic sands were widely used in the United States because there was a scarcity of good naturally-bonded sands, yet there were deposits of high quality naturally-bonded sands in almost all parts of the United States, and they occurred in enormous tonnages, if only the American foundrymen chose to use them.

He was also impressed with the summary in the last portion of the Paper, which contained a statement with regard to the well-known disadvantages of synthetic sands, as well as one or two seemingly new advantages.

The Paper was a very helpful one, and had been presented in a very pleasant way. It was divorced from much of the technicalities which tended to obscure understanding by the ordinary foundrymen, and moreover, it provided food for a great deal of thought.

What was the definition of bentonite? Bentonite in English technical literature was usually printed with a capital "B," meaning some definite article. He noticed that in the Paper it was printed with a small letter "b," as being one of a series of materials. It would help to clarify the position of sand practice, and particularly synthetic sand practice, if there was a definition of bentonite.

MR. SHEEHAN wished to thank Mr. Kain for his very kind remarks with regard to the presentation of Mr. Dunbeck's Paper. Personally, he considered it was an excellent Paper, and he welcomed the appreciation of its merits from others. Bentonite should be spelt with a small "b." There were many bentonites. There were the Canadian, Wyoming, Southern, and New Zealand bentonites. They all varied somewhat. The name, as used in this country, probably referred to a particularly important Wyoming bentonite of a very good quality.

Everybody using synthetic sands would want to make sure what it was they were getting. Anything might be sold under the name of bentonite which had even a trace of montmorillonite clay in it. He welcomed the suggestion that bentonite should be more accurately defined; but he thought it would be best left to the Technical Committees of the Institute, the Cast Iron Research Association and the Iron and Steel Institute to settle on a definition.

Clay Mixtures

MR. T. R. WALKER said that the Paper certainly contained a great deal of information. It did not mention fullers earth, a clay which resembled bentonite, as it contained a considerable proportion of a mineral of the montmorillonite type, such as occurred in bentonite. Substantial deposits of fullers earth occurred in Great Britain, and recent foundry experience had shown that it could replace bentonite for the manufacture of steel castings, giving good moulding mixtures and excellent stripping. From a green strength point of view its efficiency compared with bentonite was between 75 and 80 per cent.

Mr. Kain had pointed out that in Great Britain most people whenever synthetic sands were mentioned associated them with bentonite. In the U.S.A., however, many foundries did not use bentonite at all but used other alloys, some of which were referred to in the Paper under discussion.

Mr. Sheehan had mentioned the mixing of clays in foundry moulding materials. This was a point which would receive much greater attention in the future than it had done in the past, because of the ease with which the green-strength/dry-strength ratio of the mixture could be varied. British clays gave mixtures which had a lower green strength than mixtures containing an equal proportion of bentonite. When the green strength was made adequate by increasing the proportion of the clay, some clays gave mixtures in which the dry strength was still low. In some foundries this was no disadvantage and might even be an advantage. In other cases British clays gave mixtures with a very high dry strength, whilst at the same time the green strength was much too low. Here the green strength could be improved considerably by the addition of a small amount of fullers earth. Mr. Sheehan also referred to reports giving the properties of sand mixtures, quoting one or two figures only, for water content. In any investigations of sand mixtures, a series of samples should be tested with a water content at one end so low that the mixture could not be moulded, and at the other end so high that the mixture was too sticky to give a clean draw. In between there was a narrower range of water content within which the mixture could be properly moulded.

Unfortunately, sand testing in the laboratory was not a complete guide to the behaviour of sand in a foundry. It was not sufficient to have adequate permeability and enough green strength and dry strength. The results did not show whether the sand was capable of making a good mould, that is to say, whether it had adequate plasticity. This property was not disclosed by the ordinary sand testing methods, and it was essential to try out new mixtures on the foundry floor before satisfactory conclusions could be drawn.

With regard to Mr. Cooper's difficulty with sand mills he quite agreed with Mr. Sheehan's remarks regarding the methods of mixing sand and clay. In a good foundry, however, the mills should be inspected regularly, especially the bottom plate and the scrapers. The bottom should be in good condition and the scrapers should touch the bottom as nearly as possible to avoid the formation of caked sand. Also, scrapers should be adjusted so that they reached as nearly as possible to the middle of the mill on the one hand, and to the edge of the pan on the other hand. If this were not done the moulding time would be prolonged unnecessarily and mixing would be less effective.

MR. SHEEHAN noticed that Mr. Walker had again stressed the mixture of clays. He was glad he had done so, because it was a matter which would certainly be receiving increasing attention on the part of the technical institutes and by foundrymen themselves. It opened up wide possibilities for sand control in this country. He could assure Mr. Walker that his remarks with regard to the publishing of results obtained with a limited moisture range were not intended for his Papers. One frequently heard of results obtained not necessarily within a narrow range, but rather the comparing of bentonite at 3 per cent., with a clay of the fireclay type at 3 per cent. moisture. This was incorrect. The bentonite at 3 per cent. should be compared with the moisture content of clays which best suited the purpose.

Necessity for Standard Quality

He was in agreement with Mr. Walker's remarks concerning laboratory and foundry sand mixtures. It must be understood, however, that there was no intention to deprecate the work done in the laboratory, because the function of the laboratory was to control the sand and deliver it to the moulder or the foundry of a regular quality. If it was possible to deliver to the moulder on a set of moulding machines, or even on the floor, a regular quality, the moulder would be better served, having regard to his skill, with a bad sand of regular quality than he would with a sand which was good to-day and bad to-morrow, or good in the morning and bad in the afternoon. The great point was to deliver a sand of constant quality; the moulder would do the rest.

MR. V. DELPORT, referring to the name bentonite being spelt with a capital "B" in this country, said it was not the custom in American literature to use many capital letters. They still spelt Diesel engine in this country with a capital "D," but in America they used the small one.

MR. KAIN said that bentonite referred to an entire range rather than to one particular wonderful proprietary material. He had had great difficulty in convincing men in the foundry that bentonite was a clay and not something special. Bentonites were now on offer by various firms which, in the light of the statements contained in the Paper, might be different classes of bentonite. This point had never been made clear previously in this country. A clear definition

American Synthetic Sand Practice

of bentonite was certainly necessary. Mr. Walker had helped to clear up the point as to whether bentonite should have a sodium or calcium base.

Mr. Sheehan agreed.

Mr. Clifford suggested that a greater use could be made of the figures stated in the Paper. They were certainly much more valuable than the ordinary dry compression ratios which were usually accepted. For example, foundries making large steel castings of quite considerable tonnage but comparatively small section required a sand which was of great adaptability. The ordinary dry compression test did not afford sufficient indication as to how the sand would behave after the steel was poured into the mould. The figures stated gave much better indication as to what sand should be used.

He would have liked to have heard more about refractoriness, and also of more details with regard to the choice of clays to be used for various types of metals. With regard to the hot strength figures, he assumed that the information given applied to the actual moulds. For example, it was stated that Southern bentonite should be used for moulds for light steel castings. It seemed to him that the figures obtained, using the mixtures of clays with bentonites, would have been more useful if Mr. Dunbeck had given a range of moisture content instead of only one.

Interpretation of Data

Mr. Sheehan particularly appreciated Mr. Clifford's remarks on hot strength. It should be clearly borne in mind that the value of the hot strength figures applied when the metal had reached the mould surface; they dealt with the behaviour of the mould under conditions when the metal had been introduced. The green strength figures were more an indication of the suitability of the sand for making a mould. He regarded the green-strength figure as a measure of the quality of the sand for making a mould easily, and upon the dry strength figure and the hot strength figure as the value of the sand in respect to its behaviour in contact with the metal. It was useless having a sand which was well capable of withstanding metal impact if it were not possible to make a mould with it.

There appeared to be some confusion of thought with regard to the bentonites stated by Mr. Dunbeck for light and heavy castings. When he advised Southern bentonite for a light casting, he meant that as much of it should be used as was found suitable. Southern bentonite was recommended for light castings because it had a very low dry-strength value, and therefore the casting could contract without cracking.

Refractoriness was a very valuable property of the clays, and in America, where the synthetic sand practice was widespread, it was clay with the greatest refractoriness which was most generally used. This should be borne in mind when making a mixture of clays, particularly in the case of a mechanised foundry system, where the accumulation of undesirable fusible fines would be very rapid when using large quantities of low fusion point material.

Facing Sand Elimination

Mr. Wells asked whether filling a box entirely with synthetic sand was recommended; also whether for the basic sand an entirely new sand backed up by old sand was recommended? When using fresh sand it would appear to be possible to have a drying operation occurring prematurely.

Mr. Sheehan said that when recommending synthetic sand the recommendation must not necessarily be taken to imply that all the established naturally-bonded sand practice would disappear. It would be a mistake to consider this to be the case. There was no necessity, except perhaps for a very special job, to use a new sand in a facing. The facing sand need not be used on every job. The control was so good that synthetic sands on the floor or backing sand was usually of sufficient quantity to cast most jobs; but again this depended upon the particular foundry, the actual job being made, and the degree of finish required.

It would be desirable to dry the new sand, as a good many foundries did for their ordinary core practice. The best way of all in operating a foundry, if there were a good many cores in the work, was to select the sand with a view of it being the base sand, as well as the core sand.

The Fireclay Position

Mr. R. Turner asked whether the fireclays in America compared with those in this country. Were they a similar material?

Mr. Sheehan said they were the same. Mr. Dunbeck had mentioned a fireclay of very high plasticity. The fireclays in this country varied in themselves, as they did in America. Not every American fireclay could be used. He knew, from personal experience, that the companies which supplied these materials in America selected a fireclay which was suitable for a particular purpose, but they still retained the name of fireclay because of the refractory properties associated with the name. There was probably room for further investigation with regard to the fireclays used in this country with the object of discovering a plastic fireclay which would give a good dry-strength, and a good green-strength/dry-strength ratio.

Water—A Variable

Mr. H. Haynes did not know what quality of water was used in America, but there did not appear to be much said about water and its composition. What would be the effect on the sand in the case of a foundry situated at the coast and sea-water were used, or near a river where river-water was incorporated, and, finally, if near a canal and canal-water was used? He had attended many lectures, but had never yet heard a discussion of troubles due to contaminated water.

Mr. Sheehan said there were almost as many qualities of waters as there were beers. Sea-water, of course, contained a great deal of minerals, particularly sodium chloride. Their accumulative effect in the foundry would probably be very deleterious. It might have an immediate good effect. It would cause slight fusibility of the surface, and a scab might be avoided, but he hardly thought that it was good ultimately.

There were waters which would have to be discarded, such as those which contained much alkali or a high percentage of lime. He had never experienced any difficulty in using a particular type of water, but this was probably because the supplies which had been available to him came from municipal water-supply undertakings, and could be relied upon not to have an excess of alkalis. When taking water from a river or a canal, some investigation should be made as to its quality.

Weathering of Fireclay

Mr. Cooper said that many foundry people, when using a fireclay, sometimes did so when it was still raw. Had Mr. Sheehan found, when using a fireclay which had not been very good in the first instance, if he allowed it to stand for six or twelve months, a condition of greater plasticity prevailed? Personally, he had found this to be the case with Stourbridge, Winchester and other classes.

Mr. Sheehan replied that, if a fireclay was damped and allowed to stand for some weeks or months, it became much more plastic. The water seemed to enter into its molecular composition, or at any rate some of it appeared to do so, and improved the quality of the clay. There was such a low green strength in some fireclays that it was necessary to do everything possible in order to improve it. With highly plastic fireclays, the improvement effected by leaving them wet for a long period would be slight, and would not justify the trouble.

Mr. Cooper said that the difficulty experienced with some fireclays made into bricks depended very much upon the length of time the clay had been weathered in the open. The atmospheric effect had an important bearing upon the subsequent condition of the clay.

Mr. Sheehan, agreeing, said for foundry use the percentage value of increase in strength of a higher grade plastic fireclay would be so little that it would not be worth the trouble of weathering it. If there was, say, a strength of 10, and by weathering it could be increased to 11, then the trouble would be justified if it enhanced the refractory properties as in brick-making, but otherwise in regard to sand practice. The percentage of improvement would not justify the extra trouble.

Mill Types

Mr. Wells asked for Mr. Sheehan's opinion on the relative values of a mill with a heavy roll and a mill with a light roll.

Mr. Sheehan said that so far as synthetic sand was concerned, either was suitable. What was required was a mixing action more than a milling action. Some milling action, of course, was necessary in order to obtain the full value of the clay. If it was desirable that there should be particular economy in regard to clay additions then a heavy roller type of mill was to be recommended; but there would be heavier wear and tear on the mill, and more power would be required to drive it.

Mr. H. P. Hughes asked what Mr. Sheehan would recommend if a foundry decided to change from a naturally-bonded sand to a synthetic sand. Would he regenerate the naturally-bonded sand with a synthetic mixture, or would he use an entirely new silica sand?

Mr. Sheehan would strongly recommend a gradual changeover, particularly in the case of a mechanised system. In the case of a floor, of course, the heap could be kept separate, the synthetic sand being on one side for experimental purposes, and the ordinary sand on another side. In a previous Paper he had read in Manchester he gave all the particulars of changing over from a naturally-bonded sand to a synthetic sand, even to the extent of stating the figures for the half-way changeover, at which point he designated the sand as a semi-synthetic sand.

Mr. Hughes asked whether it was not possible to offset the difference?

Mr. Sheehan thought it might be borne in mind. He imagined that anyone wishing to change over from a naturally-bonded sand to a synthetic sand would wish to retain the best qualities of the naturally-bonded sand, for instance, in regard to finish. If the foundryman was particularly desirous of a good finish, then in the changeover he should select a fine silica sand which would at any rate approximate to the fine finish previously obtained. It was not possible to state all the points with regard to changeover during the course of a discussion, and therefore he must refer to his previous Paper.

Vote of Thanks

The Chairman then moved that a vote of thanks be tendered to the American Foundrymen's Association for arranging that the Paper should be presented to the members of the Institute, and also to Mr. Dunbeck for the original and valuable information contained in it. He would like also to couple with that vote

(*Continued on page* 126.)

Intergranular Corrosion

SIMPLE, NON-DESTRUCTIVE ELECTRICAL TEST

At a recent meeting of the American Institute of Mining and Metallurgical Engineers, a Paper on "A Simple Method for Detecting Susceptibility of 18-8 Steels to Intergranular Corrosion" was presented by H. W. RUSSELL, H. PRAY and P. D. MILLER, of the Battelle Memorial Institue. An abstract from the report in "The Iron Age" is appended.

The investigation reported by the authors was undertaken to develop a simple test procedure for detecting carbide precipitation or susceptibility to intergranular corrosion. The test is designed for use in the plant and for the testing of fabricated structures.

Carbide precipitation, the factor leading to susceptibility to corrosion, is produced by heating the alloy in the temperature range 300 deg. to 1,600 deg. F. as in welding, in improper annealing or in service where such temperatures are met. The connection between such precipitation and susceptibility to corrosion has been thoroughly discussed, as has been the use of stabilising additional elements to prevent precipitation.

In the Battelle method, a small area of the steel under test is subjected to an anodic treatment in a cell which can be clamped on to a sample or an actual structure.

The cell and electrical circuit used are illustrated in Fig. 1. The cell (C) is lead joined to the steel plate (D) and insulated from

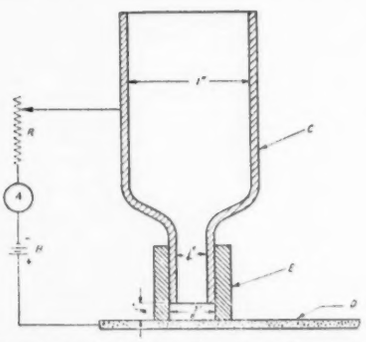

FIG. 1.—DIAGRAM OF CELL AND ELECTRICAL CIRCUIT.

it by a short piece of rubber tubing (E). The cell is forced tightly against the steel plate by a spring or clamping device. The seal formed by the rubber against the steel plate is sufficient to retain the liquid bath inside the cell. The spot treated can be made any shape desired depending on the shape of the rubber gasket. The cell illustrated polishes a circular spot about $\frac{1}{2}$ in. in dia.

Conditions of Testing

Power may be supplied by a storage battery or a battery charging rectifier. Fig. 1 illustrates a battery, the current being controlled by the resistance (R). The recommended current density is about 14 amp. per sq. in., which for the cell described requires 1.5 amp. at about 5 to 6.5 volts. The time required is 3 min.

The above conditions were chosen after a series of tests was run at current densities of 17.3, 13.9, and 10.4 amp. per sq. in. At 17.3 amp. per sq. in. it required 2 min. to obtain a good polish on unsensitised 18-8. That is, the spots produced by polishing for times less than 2 min. were somewhat frosty in appearance and could be mistaken for an indication of sensitised material. At 13.9 amp. per sq. in. it required 3 min. to obtain a good polish although a fair polish could be attained in 2 min., according to the report. At 10.4 amp. per sq. in. at least 5 min. were necessary for a good polish. The current density of 14 amp. per sq. in. and 3 min. were chosen as most practical.

When the cell is operated at 1.5 amp. the initial voltage is usually about 7.4 and the voltage gradually falls to about 5. This is due to the lowering of the resistance in the cell as the bath heats. This resistance drop is equalised by increasing resistance (R) so that constant current flows.

There is large gas evolution and much bubbling during operation so the cell was designed to minimise the effect of this bubbling.

The temperature effect is not serious unless the test is being applied to large objects. In such cases the mass of metal is so great that the heat generated in the cell is dissipated rapidly and a poor polish results. When this condition is recognised it can be taken care of in several different ways. One simple method is to heat the object to be tested by running hot water over it until it reaches 120 to 140 deg. F. In this manner the heat drain on the cell is lessened and a correct polish will result. Another is to construct the cell with more than $\frac{1}{8}$ in. between the lead and the sample and thus generate more heat in the bath due to increased resistance. A third is to increase the current density when testing large objects. The third method must be used with care because there is the possibility of polishing sensitised material if too much time or current is used. A little experimentation will indicate the best conditions to use for a particular sized object.

The bath consists of 60 per cent. (by weight) sulphuric acid to which is added 5 cc. per litre of glycyrrhiza extract (U.S.P.). The cell requires about 2 to 2.5 cc. of the bath which is discarded after each test.

Application of Method

In most cases the presence of susceptibility to intergranular corrosion can be detected as a frostiness and grain boundary attack which is readily noticeable. Partial sensitisation sometimes requires more careful examination such as viewing at various angles or the use of a magnifying lens.

Most rolled or machined surfaces can be tested without any surface preparation except removal of grease or dirt. Cast surfaces which are usually quite rough are prepared by grinding a small flat spot and then polishing with a series of emery papers to provide a fairly smooth surface. A satisfactory surface results when papers are used in the order No. 40, No. 180 and No. 1. It is not necessary to remove all scratches.

The Battelle report gave details of tests made on wrought and cast stainless steels of various analyses after the samples had been subjected to the desired heat treatments. Whenever possible the samples were water quench-annealed after heating at 2,100 deg. F. for 1 hr. to ensure that all the carbon was in solution or that there was no initial sensitisation. All tests were made with the sample initially at room temperature and using 13.9 amp. per sq. in. and $\frac{1}{8}$ in. between lead and steel panel.

Photographs were presented to demonstrate that the naked eye is sufficient to differentiate between sensitised and unsensitised material which has been subjected to the test procedure. The test is non-destructive and can be applied to completed structures.

No attempt has been made to correlate results with corrosion tests because the conditions for producing sensitised materials have already been well established.

Reports on Special-Duty Cast Irons

(*Concluded from page* 122.)

examples, the brittleness of the white iron required to withstand wear is supported by a tougher grey interior, the chilling effect not being allowed to penetrate too far. Sometimes, at the junction of the two, a recognisable mottled zone is produced, representing a mixture of the two, but mottled cast irons are seldom produced intentionally for use as such. Cast irons for malleable annealing are also cementitic as cast.

In an iron white all through, the primary grains transformed on cooling to pearlite have a Brinell hardness of 180 to 350, while the surrounding eutectic has a hardness approaching that of cementite (about 700). The mean hardness of a white iron is therefore in the range 280 to 550. The harder irons are those with the higher carbon content, and this factor determines the relative proportions of the two components.

Sub-Grouping

From the engineering or user's point of view, the pearlitic group is by far the most important and includes the bulk of the castings made. This group can with advantage be subdivided. Several possible methods of division are available; for example, on the basis of phosphorus content, as between low-, medium-, and high-phosphorus irons; on the presence or absence of alloy additions; or on the use or otherwise of special processing methods, such as ladle graphitisation ("inoculation") or heat-treatment. On the whole, however, the most satisfactory subdivision is on a basis of strength, and in accordance with existing national specifications. Such a basis gives results not dissimilar from those obtained by the other methods.

The final classification is as given in Fig. 1, the three major classes being numbered 1, 2, 3. The appropriate types in each class are numbered 10, 11, 12, 13, 20, 21, 30, 31. The ultimate subdivisions bear a three-figure number: this gives a structural classification of eleven groups, into which any grey cast iron will fit (with individual exceptions). This classification is so arranged that no cast iron can be placed in more than one group, and is, of course, capable of expansion to meet further developments.

The link between ferritic and pearlitic types, 10 : 11, and also 20 : 21, indicates the possibility of mixed ferritic-pearlitic structures.

The whole of the cast irons described in the First Report can be grouped on the foregoing basis, as can irons in other British Standard Specifications and users' specifications, although in centrifugal castings the special method of testing employed makes it difficult to classify them in parallel with other castings on a basis of strength.

American Synthetic Sand Practice

(*Concluded from page* 125.)

of thanks an appreciation of the extremely able way in which Mr. Sheehan had dealt with the discussion.

They were very fortunate in having Mr. Sheehan to present the Paper, because not only was he an acknowledged expert on sands, but he had had experience of them in America.

MR. COOPER seconded the vote of thanks, which was carried unanimously by acclamation.

MR. SHEEHAN responded suitably to the vote of thanks.

Written Discussion

MR. V. C. FAULKNER (past-President) wrote saying that from the inception of bentonite into foundry practice, he had invariably and consistently had the word printed with a small "b," because the material, like diamond or granite, was a definite mineral entity. Proprietary materials, on the other hand, carried initial capital letters.

Principles and Practice of Core-Blowing*

By H. H. JONES

The making of cores by blowing the sand into the corebox under air pressure, is an art that has been developed in the last decade. South African foundrymen have been quick to appreciate the advantages of the method, and already most of the larger foundries are using core-blowing machines, some having as many as three, five, even six machines at work. The science, however, is very new, and no text-books are available on the subject. Consequently, practical knowledge of core blowing has been confined to those who have actually worked directly with core-blowing machines in the foundry. The pneumatic core-blowing machine is intended for producing small and medium size cores in quantities, and is primarily a production machine. Given a sufficient demand for any particular core, equipment can be developed to a very high degree and a tremendous rate of output achieved, with a corresponding reduction in cost per core.

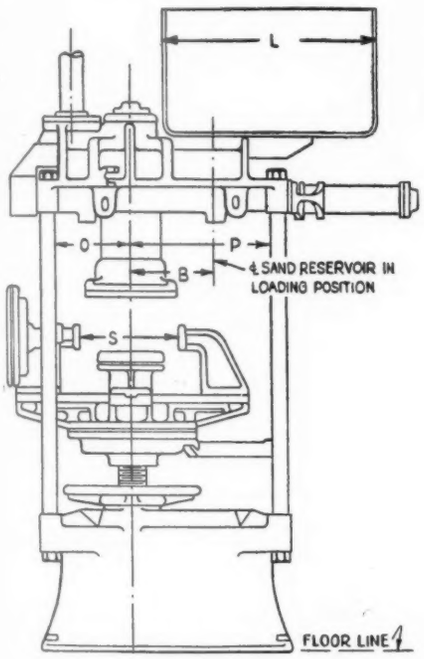

FIG. 1.—TYPICAL DESIGN OF CORE-BLOWING MACHINE.

In South Africa, several types of core are being blown in quantity, and the rate of production in some of these cases does not compare unfavourably with results obtained overseas. However, as nearly all the foundries are of the jobbing type, cores are usually required in rather small quantities, and this entails frequent changing of coreboxes. Nevertheless, many core blowers are being successfully employed in South Africa on, at any rate, semi-jobbing work, and methods have been devised to adapt the machines to this class of work. Some of these methods are decidedly ingenious, and it is interesting to learn that an American manufacturer of core blowers remarked, when told of a certain job being done here on his machines, "Well, that's a new one on us!" A number of marked advantages result from producing cores by the blowing method.

* A Paper read before the South African Branch of the Institute of British Foundrymen, Mr. W. J. Petersen presiding. The author is on the staff of E. H. Langler & Company, Limited.

Rapid Production

The most obvious gain is speed. This is influenced very considerably by various factors, including shape, size, and number of cores required, and also the degree of efficiency of the corebox and other equipment in use. In some cases the output will be forty or fifty times as high as with hand work. In others, the advantage may not be nearly so great. Each core must receive individual consideration, and it must always be decided whether a saving in the ultimate cost of production can be made by blowing the core.

Almost as important as speed, however, is the improvement in quality of the core. Blown cores will be more uniform in structure, lighter in weight and higher in strength than those produced by other methods. They will be formed more perfectly, have a higher degree of permeability, and due to their smoother skins will impart a better finish to the castings. A characteristic of a blown core is that the finer sand grains arrange themselves at the outside of the core with the larger grains in the centre. Consequently, the skin will be of maximum smoothness and the core will have maximum permeability.

Less Venting and Reinforcing

Due to this openness, the cores do not require as many gas vents. However, on large chunky cores it is sometimes desirable to use vent rods. These present no difficulty, for they may be built into the corebox in such a manner that they can be withdrawn after the core has been blown. Alternatively, after blowing, a wire can be inserted through a print, and withdrawn leaving a vent hole in the core.

The nature of the blowing operation makes it possible, quickly and uniformly, to fill corebox cavities having unusual or intricate contours that would be difficult, or impossible, to ram by hand. Since the filling is uniform, hard and soft spots are eliminated, and the core is of maximum strength; thus, reinforcing wires and rods will not be required to the extent necessary in a hand-rammed core. Usually it is possible to design coreboxes so they can be blown through a core print, or so that a core print will extend through the wall of the box to permit any necessary nails or rods to be inserted before the corebox is drawn. Openings in the top, bottom or sides of the corebox will, of course, be automatically sealed off during the blow, by the machine itself.

If wires are found to be desirable in certain small or simple cores, it is possible to place the formed wire in the corebox cavity, and the whipping action of the sand will pick up and embed the wire in the body of the core. On more difficult jobs the wire can be bedded in a handful of sand before blowing; or the rods can be supported in the core prints. In extreme cases posts can be built in the lower half of the box to support the rods, but there will be a corresponding opening in the finished core, which will have to be filled and patched after drying. In the past, not all South African foundries have made use of the great advantages of oil sand for cores.

Oil-Sand

A core blower has often been the means of introducing oil-sand cores into a foundry, yet at the same time greatly reducing the overall cost per core. Oil-sand cores have great strength when dried, and exceptional permeability; they virtually eliminate the need for nails, wires, rods, irons or vents, except for certain large cores; and the cores can be kept in stock for months without their drying out or absorbing moisture. Incidentally this latter feature aids materially in making a core blower payable in a jobbing foundry because oil-sand cores can be blown in quantities and kept on the shelf ready for use. This enables the core maker to plan out his day's work and, to a large extent, keep ahead instead of working from hand to mouth, as it were, and having to keep moulders waiting for cores.

To blow cores successfully, one must have the machine, compressed air, suitable sand, strong coreboxes, properly designed and vented; the necessary drying plates or carriers, a bench, a core oven, and some shelves for storing the finished cores.

Machines

The main essentials of a core-blowing machine are a sand reservoir with blow plate; some means of filling the sand reservoir and sealing it; and a system of horizontal and vertical clamps to hold the corebox during the blow operations.

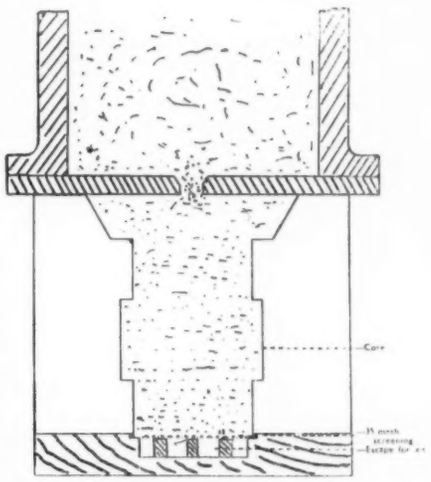

FIG. 2.—ARRANGEMENT OF VENTED BOARD ACTING AS FLOOR AND CAPABLE OF VENTING MANY DIFFERENT TYPES OF CORE.

Machines of several different designs are manufactured. The machine shown in Fig. 1 has a sand reservoir which travels back and forth from the filling position to the blowing position, on a carriage fitted with rollers running on rails in the upper structure of the frame. In the filling position, the throat of the sand reservoir is open to receive sand by gravity from the hopper. Operating a small hand-lever causes the reservoir to move under power to the blow position directly over the corebox, when blow holes, drilled in the blow plate, will correspond with blow holes in the corebox. When the foot pedal is depressed, the machine automatically goes through the following cycle of operations:—

The machine table and corebox are raised by the vertical clamp diaphragm, thus forcing the sand reservoir to rise also, and form a seal against a rubber sealing ring in the head of the machine. An automatic safety valve then makes contact, and admits air behind the main blow diaphragm, which lifts off its seat, permitting the compressed air to enter the sand reservoir. This forces the sand into the corebox. The pressure is then automatically exhausted, leaving the corebox filled. The whole operation occupies about 6 secs., no matter whether the core be small or large; or whether one core is blown at a time or several dozen.

With this type of machine a free-flowing sand must be used. If the sand is not flowable, craters will form over each blowhole, and air, only, will enter the corebox. Some core blowers

Core-Blowing Practice

incorporate an electrically-driven impeller in the sand reservoir, which permits the use of stronger sands by reducing the tendency to clog. One design employs a valve over the blowhole, which closes after each blow, thus retaining the air-pressure in the reservoir, the object being to reduce air consumption. The disadvantage of these latter types is that the machine has to be stopped, the pressure exhausted, and a cover removed after every few blows, in order to replenish the sand reservoir; and the blow area in the blow plate is strictly limited, so that it is frequently uneconomical to blow small cores (like screen cores) on machines of this design, since only one or two can be blown at a time.

Sands

The question of the sand to be used depends on the size and shape of the core and the type of metal being poured. Many kinds of sand are being employed on the Reef, from ordinary dump sand mixed with about 2½ per cent. of raw linseed oil, to quite strong mixtures containing percentages of red sand, yellow sand, bentonite, molasses, core gum, or other proprietary binders. The core sand should be thoroughly mixed, preferably in a machine, which will do the job far better and with a reduced percentage of core oil. The sand should

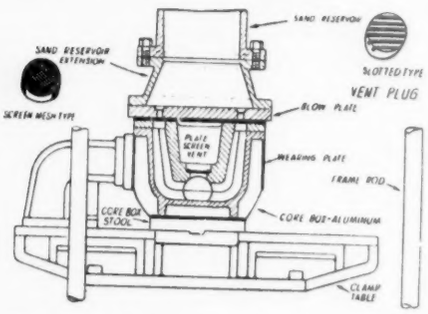

FIG. 3.—TYPICAL SCREEN VENTED COREBOX.

be placed in the mill first, the dry binder, if any, added, and after a short time, the core oil. After mixing for several minutes, water may be added to bring the mixture to the desired moisture content, and the mixer run for several minutes longer. Over-mixing should be avoided.

Coreboxes

No matter how excellent a core-blowing machine may be, it cannot blow perfect cores unless the corebox is satisfactory. Coreboxes must be properly designed, with suitable blowholes, correctly located, for the entry of the stream of sand and air, and adequate vents for the air to escape.

For high production the best results are obtained from first-class metal coreboxes having well-fitted joints throughout, and sufficient land at the parting joint and around the blowholes to ensure a good, tight seal. The outside surfaces of the box should be squared, and all opposite clamping surfaces machined parallel so that the box will clamp squarely in the machine. The boxes should be of cast iron, aluminium, or other metal, or of hard wood, depending on cost, weight, rate of wear, and amount of machining entailed. If necessary, aluminium or wooden boxes can be fitted with steel bushes or inserts at the places most subject to wear. Hard wood coreboxes have given very good results in many South African foundries, especially where the number of cores required at any one time is fairly small. Some wooden boxes have been in frequent use for as long as three or four years; they are now somewhat battered and scarred. The cores they now make have flash on them that has to be cut off with a trowel. During all this time the attitude has been that the cores were being made much more cheaply than could be done by hand, and therefore the position was satisfactory; but a certain amount of touching-up and finishing-off was always required, due to defects in the coreboxes, and undoubtedly much time would have been saved if first-class metal boxes had been made initially. If at all possible, the equipment should be such that the trowel is never needed, and can be dispensed with. Many of the cores at present used in this country have a flat surface and can be drawn on to a flat plate. Others, such as hand-grenade cores, require driers or carriers, which must be cast or pressed to shape, and are an essential part of the blowing equipment.

However, it is necessary to strike the best compromise, and such ever-present troubles as congestion in the patternshop, lack of time for experimental work, etc., have to be taken into account. The great point is that even under somewhat unfavourable conditions, the core blower can often effect substantial economies.

In this connection, prospective purchasers of core blowers, after inspecting existing installations in other foundries, have been heard to remark: "They're not getting a quarter of the work they should off that machine. Wait until we get ours going!"

Their own subsequent efforts are not always any better!

Blowholes

Except in the case of simple, straightforward cores, such as bushing cores, screen cores, etc., each new job will require individual consideration, and often the best arrangement of blowholes and vents will be determined only by actual trial. The blowholes should be from $\frac{1}{16}$ in. to about $\frac{1}{4}$ in. dia., depending on the nature of the sand and size of core. They should be located where they will do most good, and kept as few in number as possible. The object is to inject the sand into the main body of the core and induce it to flow into any pockets or narrow passages by having additional blowholes opposite these points. The blowholes in the machine blow plate should be countersunk to permit the sand to enter them more readily. The blow plate of the machine must be drilled with blowholes to correspond with those in the corebox.

In a jobbing core shop, with its miscellaneous short-run jobs, means have had to be worked out to avoid frequent changing of the blow plate. Various schemes have been adopted such as standardising the spacing of blowholes in the coreboxes as far as possible, or arranging that a corebox blanks off unwanted blowholes while utilising others. Where this cannot be arranged, the unwanted holes can be plugged. This plugging should be done so as to form an airtight seal, because air leaking through can cause a lot of mysterious trouble if it gets into the corebox; it will carry no sand with it, and will merely add to the volume of air to be exhausted through the venting system of the box.

A very effective idea for jobbing work is to cut a slot in the blow plate, probably a shorter slot crossing it at right angles. Adaptor plates of, say, $\frac{1}{8}$ in. steel plate, with suitable holes drilled in them, are then placed on top of the corebox at each blow. By this means, blowholes are made available in any part of the slot area. The addition of a couple of extra blowholes, strategically located, plugged when not in use, can almost eliminate the need for changing the blow plate. Many variations of such schemes can be worked out to suit local conditions. For instance, the adaptor plates just mentioned can be attached to the machine blow plate, with countersunk screws or by sliding into fittings, etc. The whole question is one of reaching compromise that will give the best all-round results in saving time and money.

Technique of Blowing

The corebox cavity is filled by introducing sand suspended in a stream of air under pressure. To obtain a hard, solid core, it is necessary to let the air escape back to atmosphere, yet retain the sand in the corebox. This is done by providing vents that will allow the air to flow away, but will resist the passage of the sand grains, thus trapping the sand and filling the core.

The stream of sand and air enters the box at high velocity. Upon passing from the restricted openings of the blowholes, there is an immediate expansive action of the blow stream to fill the cavity in the corebox. This action approaches an explosive condition, causing the sand grains to rebound from the point of contact with the inside walls of the box and to exert a general whipping action. Upon being released to the low pressure of the corebox, it is assumed that there is an initial drop in velocity of the blow stream, with the result that the sand grains find permanent rest. The core cavity fills first directly under the blowholes. Then, as the corebox fills, and the available room for the passage of air becomes progressively less, the velocity of the blow stream increases again, with the sand grains tending to follow the direction of the air stream

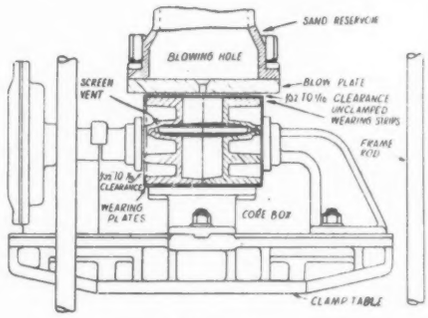

FIG. 4.—TYPICAL SCREEN VENTED COREBOX.

in which they are partially suspended. As the natural flow of the air stream is toward atmosphere, the vents should be placed in those portions of the core farthest from the blowholes and least likely to fill easily.

The air is used only as a vehicle for conveying the sand. Therefore, this air, plus the air contained by the corebox cavity originally, must be released. If it is not released, the box will contain both sand and compressed air, at the conclusion of the blow, and when the machine exhausts the core will suffer from soft spots and holes. Vents of many different sizes and types can be used. It is sometimes possible to blow small simple cores with no venting other than the natural leakage at the parting line of the corebox and at the face contacting the blow plate. Where slight venting is called for, a series of very shallow grooves can be cut in either or both of these surfaces.

This method can be improved as shown in Fig. 2. Here, shallow grooves or slots run outwards part-way across the joint, then communicate with holes drilled through to atmosphere, at an angle. These holes can be joined together by a channel and the system must be able to bleed air quickly from the grooves or slots. This scheme can be adapted in many ways to suit different coreboxes; but direct outlets to the atmosphere should be discouraged. At least one abrupt change of direction should be introduced to retard the velocity of the venting stream, this materially reducing the cutting action which tends to enlarge the vents.

Core-Blowing Practice

Venting Data

The size of vent employed is governed by the average grain size of the core sand in use; the vents should always resist the passage of the sand grains. If they do not, sand will stream out and leave a hollow place in the core. Vent plugs for coreboxes are available commercially. They are manufactured in diameters of $\frac{1}{16}$ in. to $\frac{1}{4}$ in., and some are of a type that can be machined to conform with the contour of the corebox cavity. These vents are most useful and there are few venting troubles that cannot be overcome with their aid. They are applied quite simply, by pressing them into holes drilled in the wall of the corebox, a shoulder being left in the hole to save the vent plug from being forced out by the air pressure.

Pieces of fine mesh cloth can also prove most useful for venting. They are made to form part of the floor or walls of the corebox and should be backed and faced with thin plate plentifully perforated. When blowing a number of cores at a time in a long box, open at both top and bottom, a useful method is to make up a board, faced with this fine mesh screen cloth, and cut away to provide a free escape for the released air. This vented board acts as a floor for every core in the box, and will serve to vent many different coreboxes very

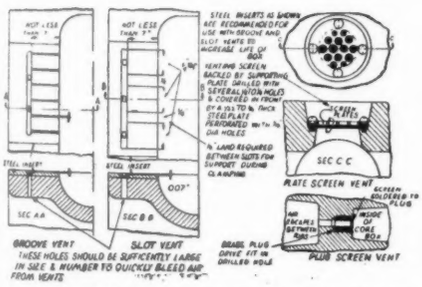

FIG. 5.—VARIOUS TYPES OF COREBOX VENTS IN COMMON USE.

efficiently, as is shown in Figs. 3 to 6. In mass-production core blowing, it is sometimes possible to provide suitable vents in the actual blow plate of the machine itself. This saves having to vent each corebox where several are in use at a time.

Limiting Conditions

Core-blowing machines are available in various sizes based on (*a*) the size of corebox they will accommodate; and (*b*) the weight of core they can blow. The size of box accommodated is governed by the size of the blow plate, machine table, and clamps. Apart from these mechanical limitations it is noteworthy that if a corebox has a greater area than the opposing clamp diaphragm (say in the case of blowing an impeller core), the pressure tending to force the box open will be greater than the pressure tending to keep it closed. The result will be that the box will gape open, and sand will blow violently in all directions.

However, if latches be fitted to the box itself, to hold it together, this limitation is overcome. In the case of boxes that are split horizontally, the side clamps are not required and can be removed from the machine if desired; much wider coreboxes can then be accommodated. The weight of core that can be blown at one operation is usually a little over one-third of the weight of sand in the reservoir. Thus, if the reservoir contains, say, 120 lb. of sand, the heaviest core that could be satisfactorily blown would weigh between 40 and 50 lb. in the green state.

In a jobbing coreshop, a core blower capable of blowing cores of about the size mentioned will be able to produce a great variety and quantity of cores. A smaller machine would be less useful for jobbing because of its more limited capacity.

Auxiliary Plant

Various developments of the standard core blower as described above are available. One type incorporates a built-in pattern-draw feature, either pneumatically or hydraulically controlled, which is ideal for certain work. Another development is a fully automatic operating valve which aids continuous high-speed production by timing every phase of the blow cycle to the most efficient speed for the one particular job. It is not suitable for jobbing work.

Other "extras" are automatic core sand feeders and elevators, corebox drawing machines; and conveyor loops or turntables, etc., which assist in handling the coreboxes. A simple, but very useful device for use when drawing coreboxes is a vertical plate mounted at the corner of the bench, and fitted with a vibrator controlled by a knee valve. This device greatly facilitates the draw operation, and saves the usual destructive rapping of the box with some handy piece of iron!

The air pressure required to operate a core blower satisfactorily is from 100 to 120 lb. per sq. in. The air consumption varies according to pressure, size of machine, and core being blown, from about $2\frac{1}{2}$ to 12 cub. ft. per blow, about 6 to 8 cub. ft. being the average. Although this consumption is not great, the volume of air is used almost instantaneously, and to avoid a sudden drop in pressure a receiver of several cub. ft. capacity must be installed near the machine, and connected to it by means of piping not smaller in diameter than the intake pipe size on the machine, usually $2\frac{1}{2}$ in. or 3 in. Provision must be made for draining off the water which is bound to condense in the receiver.

A good core blower has few wearing parts and proves very reliable in service. It should be kept clean and in proper adjustment, and any wear attended to before it begins to multiply. If this be done and sand is not allowed to accumulate and harden on the wearing surface, maintenance costs will be low. The actual operation of a core blower is very simple indeed. The patternmaker, however, finds plenty of scope for all his ingenuity in working out ever more efficient designs for his coreboxes, as experience teaches him more and more of the principles and practice of core blowing.

In conclusion, it is possible to state that almost any core can be blown, provided it is not too big to go in the machine. Unusual or difficult cores may take a good deal of time and patience before they are mastered, but the results are worth the trouble.

DISCUSSION

MR. LION-CACHET, who opened the discussion, said he had listened with very great interest to Mr. Jones' address. The only criticism he had to make was that the lecture was belated. He recalled his first experience with a core-blower. Only one little pamphlet was sent with the machine. This stated that an astonishing number of cores could be made in an incredibly short time. The machine was duly installed, and was always referred to as "she" because at first it was very difficult to know beforehand what would happen. A corebox was duly made in wood by one of the best patternmakers, who made a very accurate job. The first attempts proved entirely unsuccessful, however, because the necessity for venting had not been realised. Eventually, a job was undertaken for which an old corebox split at the back was used, and an excellent core was produced. Even then it was not realised that this result was due to the use of a split corebox. After considerable experiment they tried using fairly coarse sand and oil only. They then found that they could produce a core, but they could not carry it away. If the oil was sufficiently wet to carry it away the machine wouldn't blow, and *vice versa*. At last it was discovered that they had to get rid of the air. Ultimately they found the machine very satisfactory.

He agreed with Mr. Jones that storage of the oil sand cores made core-blowing machines suitable for a jobbing foundry, but if a machine was worked to the full capacity for which it was designed, the store would have to be as big as the foundry itself. It was due mainly to war conditions that these machines were coming into their own, but he felt that this development was beneficial and that there should be a very good future for core-blowing machines. The trouble was overcome by installing a receiver with a water drain. He thought it was an excellent thing to have lectures on core-blowing machines because of the importance of these machines to the war effort.

MR. WARD endorsed Mr. Lion-Cachet's remarks, and said that in his case the Paper was particularly interesting because his firm were experiencing their teething troubles with a core blower, and he could see that it took some time to obtain really satisfactory operation. He asked what binder was generally recognised as giving the best results. Were the

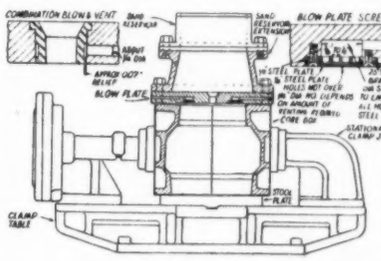

FIG. 6.—BLOW PLATE VENTING.

composition binders, generally speaking, more satisfactory than oil, molasses, dextrine, etc.?

MR. JONES suggested that some members with experience of blowing cores might care to give their views.

MR. BOYDER thought that the troubles experienced had been due very largely to regarding the machines from the point of view of "she," and tackling problems individually instead of passing on experiences for the benefit of other foundries. In the case of one of the first foundries in South Africa to instal a core-blowing machine, production was brought to perfection after months of experiment. It took five men to keep the machine going. In his opinion the question of moisture in the sand was one on which the experiences of foundries should be pooled. Different foundries used different mixtures. In one establishment a dozen mixtures were tried, but the cores were not successful because of insufficient pressure. They started with a pressure of 110, but after other machines had come into operation the pressure fell to 75 lb. per sq. in. One subject the Institute should tackle was the variation of sand in South Africa.

MR. HOLDSWORTH said he had to deal with a type of core which was made in large quantities. An oil-bonded sand was used, the cores being made in rows of five and removed on to a plate until there were approximately 200 cores on the plate. It was hoped that with the machine they would be able to run up the cores in the usual way, remove the box, and transfer the cores to the plate. Was it a practical proposition, he asked, to remove by hand, cores blown on a machine?

(*Continued on page* 132.)

Piecework and Production

By E. H. SALINGER

With regard to the article by Mr. J. C. Hallamore in the Journal of May 29, the following contribution is based on personal experience as a large employer of foundry labour. A plea is made for piecework because it yields the best results in the mutual interests of moulder and foundry, provided that the rate fixing—a matter of practice, knowledge and experience—is done correctly.

Cognisance must be taken of the equipment; the condition of the patterns; suitability of the moulding boxes; lifting facilities, and the many jobs the moulder himself has to do, which are not direct moulding, for rate-fixing must be so constituted that the average moulder is able to earn time and a quarter. The moulder who works quicker and better than the average moulder will earn even more than this, corresponding to his output.

This should be the basis of rate-fixing. It is only natural that the moulder—in his opinion—seldom gets enough, and, on the other hand, the management cannot get castings sufficiently cheaply. The ideal is for the rate fixer to be able to prove that his rating is justified, then any discontent should be avoided. The writer agrees with Mr. Hallamore that drastic changes cannot be brought into the trade in these difficult times.

On the other hand, it is contended that rate-fixing has, as a primary effect, a very large bearing on the selling price, which should be secondary. The moulder must not suffer if the foundry is selling its castings too cheaply; that is the fault of the management. Therefore, the crux of the problem is the whole complex of questions of how to fix prime costs in the foundry in a proper manner, a matter which includes the subject raised by Mr. Hallamore.

Foundries can sell their castings:—(1) At so much per piece; (2) by weight; (3) on average prices, or (4) on graded prices.

Personally, the writer has used all four methods based in every case upon the best interests of foundry and customer. The principle of true and clear prices is obviously best met by prices per piece, and if the selling price is fixed properly the foundries must have the courage to refuse the order (especially in slump times) if the buyer is not prepared to pay a fair price.

When the foundry does accept an uneconomic price, inevitable in long-term business relations, then it must know it, and it must have, in every case, a good reason why it is so doing, and secondly it must know exactly how much the loss is. Unfortunately very often the sole reason for selling at a loss is the low price asked by the competitor, or because the foundries are told so by the buyer, and they do not know how often and to what extent they are losing money because they do not calculate.

Those foundries are the cankerous sore of the whole industry, they reduce prices to an uneconomic level, resulting in no funds for re-equipment and the introduction of up-to-date methods, no earnings for discontented workmen, dearth of apprentices because young people prefer to enter more modern industries, where the work is cleaner and the possibility of making money is easier.

Floor Moulding as Basis for Discussion

From what data available can price allocation be ascertained? In the scheme detailed in Table I this is demonstrated. It is a part of the compulsory nationally-unified costing system applying to all the ironfoundries in Germany without exception, and was introduced in January, 1938. It should not be supposed this work was done by the Nazis. They have only profited from the system which the "Verein Deutscher Eisengiessereien" devised after the last war. The Nazis just made it compulsory.

If the foundry is called upon to produce intricately cored castings, light in weight, then those castings, based on a proper calculation, are best sold at prices per piece. This looks "dirt cheap" even in the eyes of the buyer, who

Calculation of Piece Cost of Iron Castings.

Date.....
Detailed description of casting .....
Customer .....
Pattern No..... No. Off.....
Net weight of unmachined casting in lbs. .....
Estimated scrap loss in lbs. = ... percentage wt. of casting.

	Estimate per piece or per cwt.	Actual cost per piece or per cwt.
Calculation of metal required.		
Amount of iron in finished casting at .... per cwt.....		
Plus amount of scrap as percentage, lb.		
Metal costs in ladle (Charge No.*) at ....sh. per lb. = ...sh. ..		
Less returned scrap lbs. at .... sh. per lb. = ... sh...		
Metal costs in finished castings per cwt. = ... sh.		
	s. d.	s. d.
(1) *Metal costs* in finished casting as given by the above per piece / cwt.		
(2) *Manufacturing costs:*		
(*a*) moulders: per piece / cwt. or time at day rate		
(*b*) Consumers' per piece / cwt. or time at day rate		
Any extra charge for special crew.*		
(*c*) Fettlers: per piece / cwt. or time at day rate		
Total		
(3) *On-costs:*		
Direct wages per cwt. ..		
Fixed overheads per cwt. ..		
Total per cwt., sum of items 2 *a*, *b* and *c*		
Related to weight ..... per lb. as percentage ..		
(4) Total		
(5) Scrap risk per cent.		
Less value of such scrap at ..... per lb. Total ..		
(6) Production costs. Total ..		
(7) Sales risk and profit ..per cent...		
(8) Total		
(9) Packing		
(10) Commission on value of line 8..		
(11) Total		
(12) Turnover tax, ...per cent. ..		
(13) Sales price at works.		
(14) Breakage insurance		
(15) Freight transport		
(16) Sales piece d/d customers' works. .. ..Total		
Costs for patterns and any finishing process by separate invoice.		

* Every charge used must be calculated on the basis of its ingredients and be given an identification number.

usually does not understand very much about the foundry business, and often thinks in the extremely old-fashioned manner that it is especially useful in the interests of his own concern, to bleed the supplying foundry.

The writer endorses Mr. Hallamore's remarks as to the "mugs of industry," but does not entirely approve of the examples of piecework rates.

If the piecework rate for the lightest weight is fixed in such a manner that an average moulder—supposing he did nothing but such jobs—should earn time and a quarter, there is no reason why this moulder should not be just as satisfied as his colleague doing a job involving the heaviest weights and with no or few cores.

If, however, the foundries only fixed prime costs for castings of such a light weight, they would be astonished to learn how wrong their sale prices were, especially in this category, which should never be compensated by piecework rates, to the detriment of the moulder.

The selling prices for castings of the light and lightest types, where the risers and runners are often heavier than the actual casting, demand special consideration for the fixing of prime costs. The principal advantage of prices by weight, especially in continuous business relations, is the simplicity of the invoicing. This advantage of simplified payment has often led to the quotation of average prices per cwt. of castings, even if the latter differ considerably in their nature and in their costings.

On account of the simplicity of invoicing, this method of settlement has great advantages to the customer, but entails, in most cases, considerable disadvantages for the foundries, particularly if the average price is not based on proper calculation but kept low by competition.

If the calculation of an average price is based on a certain proportion of the several types of castings of one order, or if in the case of continuous deliveries, the average price is quoted according to the proportion of the various castings—any change in this ratio renders a fresh price calculation necessary. The same is true of the "to schedule" prices, widely used, which are graded according to weight. These prices are also average prices, but subdivided into weight groups.

Average prices and graded or scheduled prices have their origin in those days when simple engineering designs were in use. The progressive improvement in engineering designs, the endeavour to make machines and their parts lighter for transportation and export, as well as increased demands for quality, call for a more detailed method of costing and pricing.

Foundries are, of course, endeavouring to reduce any extra costs by improving their equipment and their manufacturing processes, but they are only partially successful with this, because additional investments of capital increase the interest, depreciation and other costs.

With average prices even in cases where, for complete sets of machines, a method of calculation making a better allowance for prime costs has now been generally accepted, the prices must be further subdivided according to prime costs as hereunder:—

(1) For principal machine parts, prices per cwt. or per piece according to prime costs. (2) For different sizes of the same class or type of machines, graded prices according to weight or weight groups. (3) For accessory parts with approximately equal prime costs, average prices. (4) For accessory parts with markedly different prime costs, subdivided according to weight groups, or groups of articles.

In general, the following should be observed:—(*a*) No uniform prices for different kinds of castings; (*b*) correct calculation with widest possible sub-divisions; and (*c*) considerations of the interests of both the customer and the foundry.

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PIG IRON

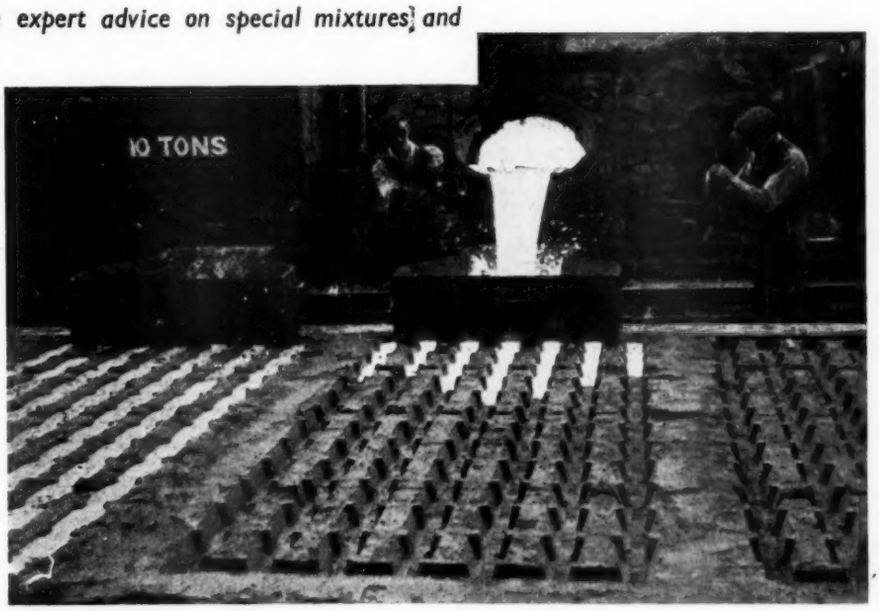
IS CHARACTERISED by closeness of grain structure, uniformity of composition and fine graphitic carbon evenly distributed.

IS PRODUCED to guaranteed analysis in seven standard grades.

CAN BE MADE to customers' individual requirements with total carbon from 2·6 per cent. upwards.

SHOULD BE USED to tone up high phosphorus irons and scrap, to replace Hematite, and to produce castings for all high duty purposes.

Users are invited to avail themselves of the Stanton Technical Service which offers free expert advice on special mixtures and other Foundry problems.



THE STANTON IRONWORKS COMPANY LIMITED, NEAR NOTTINGHAM

Piecework and Production

The writer agrees with Mr. Hallamore that it is only by a united effort that such demands can be secured on behalf of the ironfoundry industry. This, as a personal opinion, is one of the more important tasks—if not the chief task of all—of any centralised employers' association which may be formed with the co-operation of all the ironfoundries in the country. Only such a body is in the position to make that effort and so help the industry itself. The individual ironfoundry is usually too weak to assert itself successfully.

The writer also endorses Mr. Hallamore's remarks as to the loss of vital production time. A moulder should be occupied, if at all possible, only with moulding. This, however, is a question of organisation and much depends on the size of the foundry, the kind of castings it is doing and the preparation before starting the job.

A well-organised management will line up with the times, not only in commercial and technical matters, but will also not neglect to look after the welfare of the workpeople and their major and minor troubles. In such matters the workers have a very fine understanding and by so doing one can easily raise the spirits of the whole staff. This is to be seen in quite a number of undertakings in this country, but in many others, much still remains to be done.

The worker is in many cases often in a position to suggest remedies for improvement and thus keeping down cost of production. For that he must receive a reward corresponding to the usefulness of his proposals. This fact must be made public each time on the notice-board for the encouragement of others.

Good workpeople and a loyal staff are not only very important for the successful running of a concern, but are a part of the working capital and with such a body of men, with the necessary tact in introducing new methods and with proper treatment of them as human beings, the writer has found with his long years of practical experience that it is not so difficult as it seems to increase quality and quantity of production by piecework in the foundry.

Costing—Principles of Calculation

Taking all the overhead expenses as a certain percentage on the wages, the price of castings on which high wages have to be paid, turn out to be too high, and the castings cannot be sold for this calculated price, whereas the prices of castings on which little was paid in manufacturing wages turned out to be unjustly low.

Without going too much into details here, the following subdivision was the result of the efforts made by foundry experts in Germany during the last 20 years:—

1. Liquid metal costs.
2. All manufacturing wages.
3. Overhead expenses.
   (*a*) Related to wages.
   (*b*) Related to weight.
   (*c*) Fixed (non-proportionate) expenses.

Manufacturing wages comprise moulders, coremakers and fettlers.

Overhead Expenses are made up of those: (*a*) *Related to wages*, such as wages for unskilled workers in moulding, coremaking and fettlings shops; wages for handling, crane operators, and holiday wages for the whole staff; wages for maintenance and repair in foundry and fettling shop. Social expenses for workpeople, including insurances.

(*b*) *Related to weight*, such as auxiliary materials for the moulding, coremaking and fettling shops (chaplets, core nails, core oil, parting powder, coal dust, graphite, sulphite lye, molasses, pins, sand, flint, rattler stars, steel grit, grinding wheels, lubricating oil, cleaning materials, etc. Price for materials to include carriage).

Other materials consumed include the replacement of tools (in monthly portions); replacement of moulding box and castings for the foundry's own inventory (in monthly portions); fuel, gas, oil (apart from the melting unit), water, compressed air, power water, steam costs, electric power and light, repairs done by outside firms, costs of patterns for the foundry's own castings (in monthly portions); cartage and other transport costs; and freight and carriage cost for rubbish and slag, carried out by the foundry's own lorries or by outside firms.

(*c*) *Fixed Costs.*—All salaries and pensions (premiums), wages for permanent employees (doorkeepers and drivers), works' and office staff (apart from melting department); social payments for the above and for salaries of the melting department, including part of insurance; voluntary social donations and welfare work; depreciation of buildings, machinery, works' and office equipment, rent, lease and maintenance of buildings; cost of pattern storage and maintenance; commercial insurance of all kinds, except breakage insurance; taxation of all kinds (trade, ground and rent taxes), except personal taxes of the owner, as for instance income-tax; payment of interest for investment and working capital, other than administration costs, such as travelling and advertising expenses, Court fees and legal costs, other fees, subscriptions to federations, associations, Chambers of Commerce, etc., and maintenance of passenger cars; all office expenses, office material, repair of office equipment, office heating, lighting, cleaning, postage, telephone, newspapers, periodicals, etc.

If this article helps to convince those foundries, which have failed hitherto, to their own disadvantage, to realise the necessity of calculating their costs in detail, then its purpose has been fulfilled.

Casting in Rubber Moulds

"Steel" has printed a full-length article devoted to the production of, mainly, jewellery castings in rubber moulds. The upper temperature limit for the alloy to be used is of the order of 300 deg. C. Most of the castings made by this thoroughly well-established process are made by the horizontal centrifugal casting process, whereby a number of moulds are placed around the periphery of rotatable plate, and are connected to a centrally disposed runner by a number of gates. If space permits, we hope to reproduce a lengthy abstract of this article in the future.

Adhesions in Blast Furnaces

The nature, composition and distribution of adhesions and accretions in the blast furnace have been studied by M. B. POSIN. In "Teori. prakt. met.," he reports that the blast-furnace dust generated contained a high percentage of alkalis and sulphur, while the iron content increases with diminishing distance between the bell and hopper and the top edge of the furnace. Adhesions were observed about 7 m. above the tuyere level, and are vitreous owing to the sodium content: their formation is favoured by an irregular distribution of the burden and the unilateral injection of water. Various measures are recommended by the author for preventing these accretions.

International Nickel Company of Canada

For the six months to June 30 the International Nickel Company of Canada, Limited, and its subsidiaries earned a net profit of U.S. $17,315,607 (after providing for income and franchise taxes), equivalent to $1.12 a share on the 14,584,025 no par shares of common stock outstanding. This compares with a net profit of $18,060,293, or $1.17 a common share, for the corresponding period a year ago, and $17,773,438, or $1.15 a share, for the first six months in 1939. Provision for income and franchise taxes in the six months ended June 30, 1941, amounted to $15,189,325, or $1.04 per share of common stock, compared with $9,246,823, or 63 cents per share, in the first six months of 1940, and $4,437,245, or 30 cents per share, in the first half of 1939. Net working capital on June 30, 1941, amounted to $76,865,163, against $76,920,900 on March 31, and $69,107,658 on June 30, 1940.

Principles and Practice of Core-Blowing

(*Concluded from page* 129.)

MR. LION-CACHET said this could undoubtedly be done without the use of any fancy carriers, if they persevered.

MR. WARD explained that the machine referred to had only been in operation for a couple of days. The pressure was satisfactory, but so far they had not yet succeeded in finding a mixture which would flow and at the same time would produce a strong core.

Author's Reply

MR. JONES, in replying to the points raised, said he was not there to defend the blower, but only to describe it. He hadn't previously thought of blowers as being feminine in nature. However, he reminded the meeting that only the brave deserve the fair, and the reward was worth the seeking. Mr. Lion-Cachet had mentioned the necessity for dry air. It was certainly necessary that condensed water should be drained off. As regards the various binders, it was unfortunate that Mr. Ward's experience had been so short. He believed that if the meeting had been a month later there would have been a different story to tell. It was very rarely that a South African foundry got good results immediately from a blower which had just been installed. It was first of all necessary to get to know the machine. Within two or three weeks, however, beautiful cores were usually being blown with complete regularity.

In many foundries blown cores were being picked up; with a suitable corebox, however, there was no need to pick up cores, as the cores could be produced in good formation ready for the oven. Where a proportion of the cores produced were faulty the trouble was generally due to venting. Instead of venting to the atmosphere the corebox might be venting from one cavity to another, and this would not occur if the venting of each cavity was separately carried out. Variations in performance were usually traceable to variation in the sand or pressure, and in some cases it was actually advisable to dry the sand right out before starting to prepare it, so that the exact water content might be known. Every core should be studied, and in the jobbing foundry every range of cores should be considered on its own merits with a view to discovering whether any saving in the ultimate cost of production might be effected. That blowers were giving satisfaction seemed clearly indicated by the fact that a number of foundries which started with one blower, now had several in use.

MR. LION-CACHET said that core-blowing machines were becoming fashionable, not as clothes were fashionable, but rather in the manner of motor-cars, refrigerators or radios. Once motor-cars went at about 25 miles an hour and frequently broke down, but the performance of the modern car was vastly different. Core-blowing machines were already blowing from 1,200 to 2,000 cores per hour, and he looked forward to the day when 10,000 an hour would be blown. He certainly thought that in South Africa core-blowing would advance at the same pace as in any country overseas, particularly if local foundries were prepared to learn from the experience gained overseas.

Foundry Sand Problems

Prof. E. J. Ash and Mr. Erik O. Lissell, writing in "The Foundry" on "Some Fundamental Aspects of Foundry Sand," state that "considerable criticism regarding the method adopted by the American Foundrymen's Association for preparing the standard compression test for sands has been offered by Buchanan, FOUNDRY TRADE JOURNAL, 1933 and 1937; this is well founded, and worthy of consideration in research work."

Pig for Victory

We have amended the popular slogan because most of the qualities required for victory are inherent in Warner Pig Iron.

Toughness — Resistance to wear and tear—Strength—Uniformity — Reliability — and Economy, to mention but a few.

Admittedly, we can think of no spiritual virtues which Warner Pig Iron can contribute to the winning of this war — although our artist obviously regards it as pig-headed and we can at least hope that this will confirm the worst suspicions of the enemy regarding everything British.

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The Week's News in Brief

Trade Talk

ALUMINIUM UNION, LIMITED, has removed from the Adelphi to Grosvenor House (8th Floor), Park Lane, London, W.1. The telephone number is Grosvenor 4941.

BRITISH MOULDING MACHINE COMPANY, LIMITED, have moved their offices from their temporary address at Park Cottage, The Common, Sevenoaks, to 1, East Street, Faversham, Kent. (Telephones: Faversham 2246/7.)

OWING to the continued success of the lectures on "Foundry Practice," even during the black-out, at the Royal Technical College, Glasgow, evening classes, where Mr. Wm. M. Buchanan has been lecturer for the past 5 or 6 years, the Governors have decided to extend the course from 25 to 50 lectures this winter.

THE MINISTRY OF LABOUR announces that the number of men and boys registered at employment exchanges in Great Britain as wholly unemployed at July 14 was 113,662, a decrease of 7,900 as compared with June 16. Of this total 33,048 had been classified by interviewing panels as unsuitable for ordinary industrial employment.

PRODUCTION OF MALLEABLE IRON CASTINGS in the United States during the first five months of the current year total 344,729 short tons, an increase of 61.5 per cent. over the 213,456 tons produced in the corresponding 1940 period, according to the U.S. Department of Commerce. In the first five months of 1929 output totalled 395,750 tons, and in the like 1937 period 297,829 tons.

THERE HAS BEEN A BOOM IN ORDERS for guttering and fall pipes. This follows on the heavy falls of snow earlier in the year with consequent damage to existing fittings. This has helped to create a congestion already bad enough owing to the shortage of such goods, and as a result much of the business placed months ago is only being supplied now. Fall pipes are difficult to obtain and guttering more so.

IN A LETTER to business and industrial concerns, Lord Beaverbrook, the Minister of Supply, points out that he wants to reduce the amount of form-filling hitherto required of firms engaged on war production. In carrying out this intention, he says, we must on no account interfere with the complete record of information relating to production. That is entirely essential to the efficient conduct of our programmes. But in other directions there may be relief.

REPRESENTATIVES of the Engineering and Allied Employers' National Federation met the Confederation of Shipbuilding and Engineering Trades in London last week in connection with an application for an increase in wages. The conference, after hearing the union's case, adjourned to give the employers an opportunity of considering the proposals. A similar application is being made by the Amalgamated Engineering Union and the National Union of Foundry Workers. Their officials will meet the employers this week.

THE MINISTRY OF LABOUR, in conjunction with the Board of Education, are taking steps to increase the supply of foremen by establishing special training courses at technical colleges throughout the country. The course, the cost of which will be borne by the Ministry of Labour and be free to the trainees, will cover general principles of foremanship and supervision, principles of production and planning, elements of labour management, and costing and remuneration, and will consist usually of evening lectures, although the possibility of week-end classes is being considered by certain authorities. Employers have been invited to forward men with the requisite technical knowledge and personality for supervisory positions. To meet the need for machine-tool setters, the Ministry of Labour have arranged a special course of training for selected men. Under this particular scheme, employers will release suitable employees, continue to pay them normal wages during training, and take them back to their works when the course is completed. Training may take place at a Government training centre or at a private firm, and, where this involves the men being away from home, travel and lodging allowances are paid by the Department.

Personal

MR. TOM SWIFT PEACOCK, of Darlaston, will shortly be retiring from the position of managing director of Guest, Keen & Nettlefolds, Limited, which he has held for the past 22 years. He will remain deputy chairman of the company. He is 72 years of age.

MR. FREDERICK GEORGE BINNEY, export manager of the United Steel Companies, Limited, was knighted by the King on Thursday of last week. He has been with the Iron and Steel Control for some time past and his knighthood was announced in the Birthday Honours last June "for special services in the supply of valuable war material."

MR. ARNOLD CARR, who has recently been appointed to the full board of directors of Thos. W. Ward, Limited, Albion Works, Sheffield, was on Saturday last a guest of his senior staff at a luncheon held at the Royal Victoria Station Hotel, Sheffield. On this occasion Mr. Ashley S. Ward, the chairman of the company, made a presentation to Mr. Carr on behalf of his staff, of a silver salver suitably inscribed and cocktail shaker, etc., as a mark of their esteem.

Wills

MACDONALD, R. M., of Hoylake, partner in G. Rae Anderson, iron and steel merchants...	£10,655
SENIOR, EDWIN, who was in control of the forge department of Thomas Firth & John Brown, Limited, Sheffield	£3,222

Obituary

MR. LESLIE FYVIE, district engineer for Belliss & Morcom, Limited, engineers, of Birmingham, has died.

MR. HARRY PARSONS, of Coventry, has died, aged 55. He was managing director of Pistons, Limited, which he founded in 1912.

MR. JOHN WILLIAM COOK, formerly managing director of Cook & Company, Manchester, Limited, textile machinists, died recently.

MR. ARTHUR GRAHAM PRIMROSE, of Glasgow, chairman of Dickson & Mann, Limited, colliery engineers and steelfounders, died on August 6, aged 57.

MR. HENRY GARDINER ATKINSON, chairman of Benton & Stone, Limited, brassfounders and tube makers, Birmingham, has died at the age of 77, after a long illness. He took an active part in the work of the Federation of British Industries, and during the last war was joint managing director of the National Shell Factory, Birmingham.

MR. JOHN THOMAS TWEEDALE, a son of the late Mr. Edmund Tweedale, one of the founders of Tweedales & Smalley (1920), Limited, textile machinery makers, Castleton, Rochdale, has died, aged 76. Mr. Tweedale was first associated with the company in the outfitting department, later having charge of the metal mixing department. He retired from the firm in 1919.

SIR CORNELIUS CHAMBERS died after a long illness at Shirley, Birmingham, on August 6. He was chairman and managing director of Gaskell & Chambers, Limited, coppersmiths and brassfounders, Birmingham, and of subsidiary companies. Sir Cornelius was a liveryman of the Pewterers' Company. A knighthood was conferred upon him in 1933. He was 80 years of age.

MR. ARTHUR CHAMBERLAIN, who died at his Devonshire residence on August 7, was chairman of Tube Investments, Limited, and Churchill Machine Tool Company, Limited, and a director of General Electric Company, Limited, Stewarts and Lloyds, Limited, Tubes, Limited, and the Iron Trades Employers' Insurance Association, Limited. Mr. Chamberlain, who was a cousin of the late Prime Minister, Mr. Neville Chamberlain, was 61 years of age.

New Companies

("Limited" is understood. Figures indicate capital. Names are of directors unless otherwise stated. Information compiled by Jordan & Sons, 116, Chancery Lane, London, W.C.2.)

Mills Engineering Products—£2,000. R. G. Mills, 37, Repton Road, Kenton, Middlesex.

Bardsley Jig & Tool Company—£2,500. C. Terry, Manor House, Knotts Lane, Bardsley.

Metal Abrasives, 190, Piccadilly, London, W.1—£7,000. L. O. Evans and A. B. Porter.

E.M.S. Precision Tools—£500. A. D. Martin, 119, Grove Lane, London, S.E.5, subscriber.

Reports and Dividends

Linley Engineering—Net profit for the year ended March 31, £1,313 (£1,236); first and final dividend of 5% (same).

Scottish Machine Tool Corporation—Net profit for the year ended March 31, £74,865 (£72,444); final dividend of 3½%, making 6% (8%); to reserve for tax, £57,900 (£39,750).

Wm. Neill & Son—Second interim dividend on the ordinary shares of 1¼d. per share actual, less tax, for the year ended March 31, making a total to date of 3d. per share (same).

Fairbairn Lawson Combe Barbour—Net profit for the year ended March 31, subject to E.P.T., but after charging tax and added to the balance brought in, £216,344; dividend of 10% (5%) on the preference shares, less tax; carried forward, £207,926 (£104,908).

Consett Spanish Ore—Net loss for the year ended June 30, £1,608 (net profit £4,240); to writing down investments, £12,500 (nil); brought in, £16,096; carried forward, £1,988. Owing to difficulties in Spain and consequent depreciation in value of shares held in Orconera Iron Ore, it has been found necessary to write down this investment by £12,500 and, therefore, the directors are unable to recommend a dividend (10%).

Manley & Regulus—Profit for the year ended April 30, £56,886 (£22,786); maintenance and depreciation, £18,474 (£8,688); preference dividend, £1,400 (same); A.R.P. expenditure written off, £1,301 (£869); taxation reserve, £13,804 (nil); special war obsolescence and maintenance, £5,000 (nil); final dividend of 5% actual, less tax, on the ordinary shares, making a total of 10% (same); carried forward, £23,245 (£19,711).

Brush Electrical Engineering—Net profit for the year ended December 31, after providing for general charges, interest on debenture stocks, depreciation, war risks insurance, etc., added to the balance brought in, £63,432; preference dividend for half-year to September 30, £3,163; provision for preference dividend for half-year to March 31, £3,162; written off patents and goodwill, £10,568; written off A.R.P. expenditure, £7,740; war damage insurance, £2,760; to general reserve, £25,000; carried forward, £11,039.

Iron-Foundry Workers

CHANGES IN RESERVED LIST

Following the changes in the Schedule of Reserved Occupations affecting steel-foundry workers, reported in the FOUNDRY TRADE JOURNAL of July 31 last, amendments have now been announced affecting workers in iron foundries. The first set of ages in the list below relates to reservation at Stage B, which came into operation on July 1: the second group relates to Stage C, which will come into operation on a date yet to be announced. The first age in each pair relates to reservation in protected establishments, and the second to reservation in other establishments, *e.g.*, moulders (general hands) are reserved at the age of 23 if they are working in a protected establishment, but are not reserved until the age of 35 if they are engaged in non-protected establishments. It will be noted that the ages are the same at both stages in the following complete list:—

Moulder (general hand), 23 (35); 23 (35). Cupola man, general furnace attendant (iron foundry), 18 (35); 18 (35). Coremaker (iron castings), 21 (35); 21 (35). Caster, pourer, 18 (35); 18 (35). Bench moulder, 23 (35); 23 (35). Floor moulder, 18 (35); 18 (35). Oddside moulder or plate pattern moulder, 18 (35); 18 (35). Plate moulder, 18 (35); 18 (35). Spray moulder, 21 (35); 21 (35). Stump moulder, 18 (35); 18 (35). Tub moulder, 18 (35); 18 (35). Machine moulder, 23 (35); 23 (35). Matrix maker, pattern moulder, 18 (35); 18 (35). Cylinder moulder, 23 (35); 23 (35). Roll moulder, 18 (35); 18 (35). Dresser, fettler, and chipper, 21 (35); 21 (35).

A new reservation introduced into the Schedule is that of cold stamper, for which the age of reservation in protected establishments is 25 at both stages. There is no reservation for these workers in establishments that are not protected. This addition to the Schedule is not retrospective and does not involve the release of men already called up.

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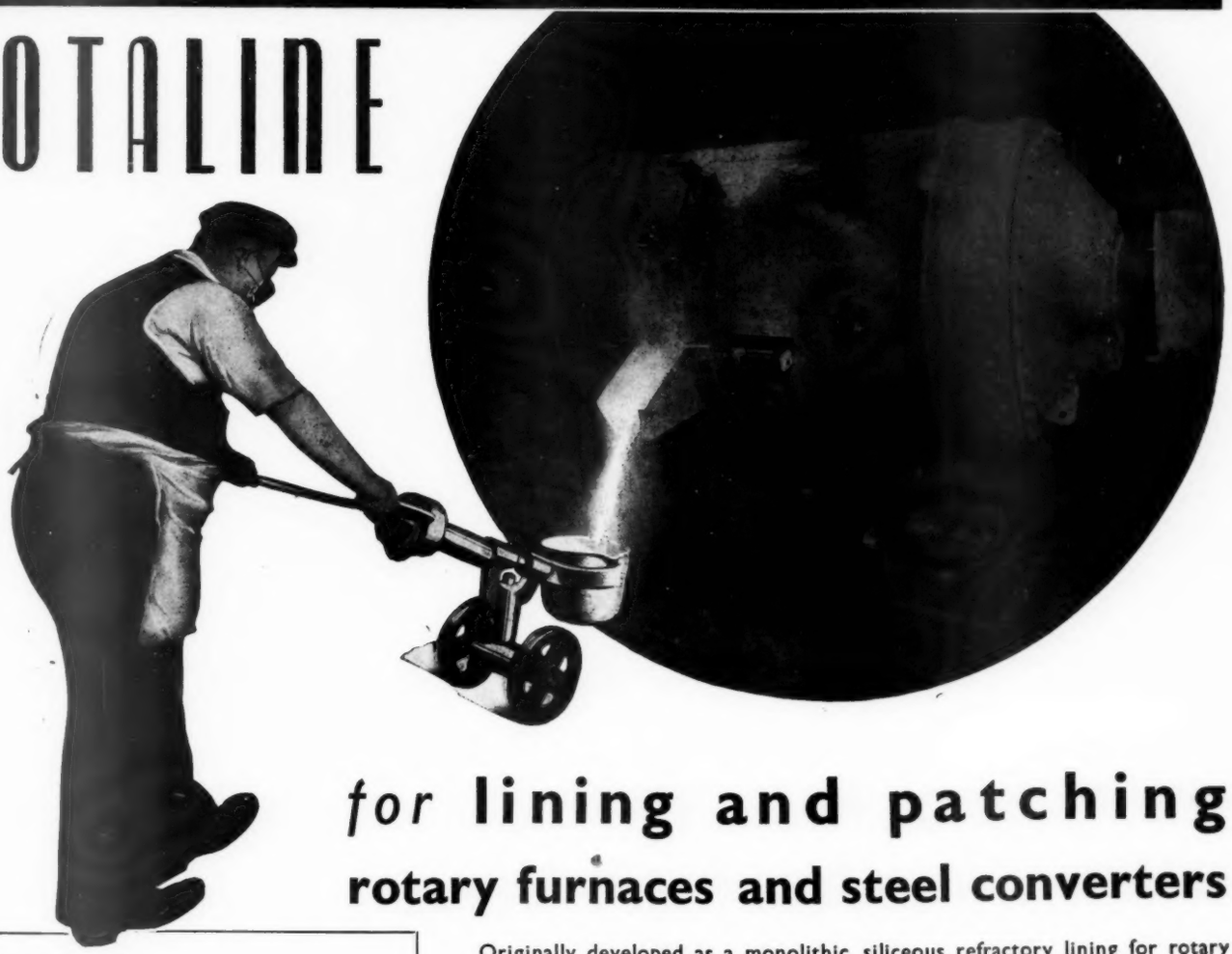

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ROTALINE: For rotary furnaces melting grey iron, malleable iron, and steel: Stock and Tropenas type converters, hearths of receivers, melting furnaces, etc.

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Originally developed as a monolithic siliceous refractory lining for rotary furnaces, Rotaline is also widely used as an efficient lining in steel converters, electric rotary furnaces, and for the hearths of receivers and melting furnaces in the ferrous and non-ferrous industries.

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ACID-PROOF REFRACTORIES: *Obsidianite, Losol.*

INSULATION: *Amberlite* Bricks, Cement and Concrete.
SILICA BRICKS: *Lowood, Meltham, Allen, Quartex.*
CEMENTS: *Sintex, Durax, Pyrolyte.* PLASTICS: *Durax, Rotaline, Plastic K-N., Glendoline, Ground Ganister., Steel Moulders' Composition.* SILLIMANITE: *Tank Blocks, Bricks and Cements.* SANDS: *Moulding, Brick Facing, Silica, Glass.*

Raw Material Markets

There is a lull in the demand for certain steelworks' products and, generally, the total weight of specifications has declined. As a result, some of the mills are short of orders. The reason is not far to seek. Since the war began the efforts of the Iron and Steel Control have been devoted to the supplying of war needs, while providing only a minimum quantity for civil uses. These efforts have been successful. The civilian use of iron and steel has been cut to the bone, while production and distribution have been so organised that the stage has been reached when the country is able to meet all the demands of the war machine for raw steel. All requirements for the war effort are now being met without difficulty, and the exclusion of ordinary commercial transactions has rendered a certain amount of productive capacity temporarily redundant. Labour and materials will thus be freed for more essential sections of the trade.

Demand for alloy steels is still increasing, but the rate of increase in this direction is not altogether offset by the fall in the demand for certain ordinary steels, and the net result is a decline in total steel production. Sheets and tinplates are two of the products which are particularly affected by the changes in production and distribution wrought by wartime considerations. The foundry trade felt the effect of these changed circumstances much earlier in the war. Steel foundries and foundries attached to the heavy engineering and machine-tool industries have been uniformly busy since the outbreak of hostilities, whereas the light-castings trade, producing mainly for the building industry and export, has found great difficulty in keeping its various units adequately employed. The low ages of reservation for steel foundry workers and the distinction now made between protected and unprotected establishments in the iron foundry trade, are indicative of the determination of the authorities to concentrate on war production, to the rigid exclusion of non-essential uses of materials and labour. In the non-ferrous section, also, supplies of metal are forthcoming only for essential needs.

Pig-Iron

MIDDLESBROUGH—Production of foundry iron on the North-East Coast is now on a very small scale. Cleveland blast furnaces are concentrating mainly on basic iron for the steel furnaces, with a smaller production of hematite, ferro-manganese and refined iron. The exigencies of war have enforced on the district a withdrawal from the trade in Cleveland foundry iron, which in other, now long distant, days was its mainstay and its pride. The trade in Cleveland pig-iron with every district in England, with the Falkirk and other Scottish founders, and with the four quarters of the globe may return sooner than at present appears to be possible, but at the moment the wartime task of the furnaces on the North-East Coast is the supplying of the needs of the steel industry. Local foundries are not inactive, but they draw their supplies of iron from the Midlands of England and not from the furnaces on their doorstep. Ample tonnages of Midland high-phosphorus iron are available, and foundry owners are being encouraged by the Control to acquire supplies in excess of immediate needs while transport conditions are favourable, so that they may have a reserve against the uncertainties of the winter.

Demand for hematite continues to be in excess of the supply, and a ready market exists for all the East Coast furnaces can supply. There is no prospect at the moment of an appreciable increase of the make, and hematite users are being urged to utilise in their mixtures as much scrap and high-phosphorus and refined iron as possible. Distribution of hematite is strictly controlled, and despatches are made only to works which cannot do without this grade of iron. Prompt delivery is made of authorised tonnages, and in some instances essential users have been able to acquire small reserve supplies.

LANCASHIRE—Most of the light-castings establishments in Lancashire are indifferently placed, and their requirements of high-phosphorus pig-iron are therefore on no more than a modest scale. Some of the jobbing foundries are well employed, but others would welcome orders. Textile-machinery makers are relatively poor customers of the pig-iron manufacturers. The heavy foundries, on the other hand, are very busily employed, and satisfaction of their demands for low-phosphorus iron and hematite is not always easy. Distribution of hematite in this area is very carefully controlled. Staffordshire and Derbyshire makers of high-phosphorus iron receive a steady flow of orders, but do not appear to have any difficulty in meeting the call for deliveries against the licences granted by the Control.

MIDLANDS—The many light foundries in the Midlands of England continue to be only moderately employed. There are exceptions, of course, but the light-castings trade as a whole has been unable to secure sufficient Government work to keep plant and men fully employed. The requirements of these foundries are largely in the high-phosphorus grade, produced from home ores, and they have no difficulty in getting authorised supplies from the Midland blast furnaces, which, indeed, are supplying in addition the light foundries in Scotland, Cleveland, Lancashire and other parts of England. The furnaces have good reserves of iron, and the Control is permitting also the accumulation of reserves at the foundries. Active conditions continue to prevail at the heavy engineering foundries, and there is some difficulty in meeting promptly their calls for the grades of pig-iron needed for their specialised work. Supplies of the low-phosphorus and hematite descriptions of iron formerly used are being supplemented by tonnages of refined and high-phosphorus iron as well as ferro-alloys and steel scrap. Mixtures have had to be rearranged, generally successfully. Where hematite is essential, supplies are forthcoming from the Control. There are ample supplies of forge iron available for the wrought-iron manufacturers, who are passing through a dull period.

SCOTLAND—As is the case with similar establishments in other parts of the United Kingdom, the light foundries in Scotland continue to feel the lack of the pre-war flow of orders for domestic castings, and war work is not available in sufficient volume to make good the deficiency. Adequate supplies of foundry iron are available from the English furnaces. The heavy foundries are busy and are able to get their requirements of Scotch iron. Hematite is not plentiful, but there is no actual shortage.

Coke

Deliveries of foundry coke continue to be sufficient not only to cope with current needs, but also to permit stocking on a moderate scale. Most of the larger consumers have already laid down reserves, which should be especially useful during the winter months. For delivery to Birmingham and Black Country stations, the price of Durham best foundry coke remains at 62s. 9d. per ton. It had been expected that the Control authorities would have sanctioned an increase in the quotation for Durham fuel before this, but so far no intimation of an advance has been received.

Steel

Ordinary steel continues to be rather quieter than in recent months, and the tendency is for this grade to make way for alloy steel, which is in very heavy demand for the production of munitions, etc. Joists, sections, and other descriptions of structural steel are now available much more freely, and structural engineers, on the whole, are in a position to accept additional business. Shipbuilders' demands for steel plates, etc., are fully sustained and no relaxation in this section is likely for a long time to come, so active are the shipyards. The requirements of tank and boiler makers are substantial, and good orders are emanating from these concerns. Sheet mills in some instances would welcome fresh business.

Scrap

There has lately been a slight seasonal decline in the call for certain grades of scrap, but the fall is not to be compared with the lull which usually sets in about this period of the year in normal times. Steelworks have not suspended deliveries and the pressure for supplies from this source is heavy and unabated; some other consuming works asked for supplies to be withheld during the time they were on holiday, but in the steel industry it was deemed prudent to place the deliveries into stock at the works.

Metals

COPPER—The Control continues to scrutinise carefully all applications to acquire copper. All essential needs are being met without difficulty, but a close watch is kept on consumption for ordinary domestic purposes. Consumption of copper in the United States continues to increase, and in that country also steps are being taken to cut down the use of metal for purposes outside the defence programme. Priorities have been introduced by the United States authorities in the interests of munitions production, and a maximum price for copper has been laid down, the upper limit being 12 cents per lb. delivered Valley. There are producers who cannot sell commercially at this figure, and the new price decree does not, presumably, rule out the possibility of the output of these producers being acquired at some higher figure by special arrangement. There is no real shortage of copper in America, but a lot of the available metal has been used for non-essential needs. What amounts to full control of copper supplies has now been undertaken, and it is evident that the U.S. authorities have no intention of letting their war programme be held up because of a scarcity of this essential metal.

TIN—The tin market this week has not been particularly active. Export licences are still suspended and, as a result, stocks in this country are on the upgrade. Official policy has undoubtedly operated in the national interest, but activity on the London Metal Exchange has thereby been greatly restricted, turnover being only a third of what it was earlier in the year, before exports were banned. There was to have been a meeting this week of the International Tin Committee, but it has been postponed to a date that will be announced later. A report that a sales cartel arrangement had been arrived at between the Banka and Billiton companies has been officially denied.

According to a report from New York, the Metals Reserve Company has negotiated with Banka tin interests for the purchase of concentrates containing 20,000 tons of refined tin from the Netherlands East Indies. The concentrates will be shipped to the new tin smelter at Texas City, which is expected to be completed this winter. The smelter will also refine Bolivian ore. It is reported that a maximum price for tin has now been adopted in the United States. The U.S. tin market is active, for consumption is high and there is also a desire to accumulate a substantial reserve of this metal in America, where there are no native tin deposits. Details of Straits shipments and outputs will not in future be available for prompt publication, and the statistical position will be correspondingly more difficult of analysis. It is well known, however, that production is in excess of consumption, the surplus being prudently placed to stock here and in America.

Tin prices on the London Metal Exchange during the past week have been as follow:—

Cash—Thursday, £258 15s. to £259; Friday, £258 5s. to £258 10s.; Monday, £257 10s. to £257 15s.; Tuesday, £257 5s. to £257 10s.; Wednesday, £256 15s. to £257.

Three Months—Thursday, £260 10s. to £260 15s.; Friday, £260 5s. to £260 10s.; Monday, £260 10s. to £260 15s.; Tuesday, £260 to £260 5s.; Wednesday, £259 15s. to £260.

SPELTER—Production of spelter continues in a satisfactory manner, and war needs here are being met. There cannot, however, in the nature of things be much to spare for other purposes, and in actual fact a close eye is kept on distribution of this important war metal. The necessity of bringing in concentrates in itself imposes careful allocation, because of the need to economise in shipping space. Output in the United States is growing, but is also conditioned by the tonnage of concentrates for which ships can be found.

LEAD—The supply position in this metal remains satisfactory, and no difficulty should be experienced either here or in America in meeting the needs of the war machines. Releases, however, are made according to the importance of the use to which the metal is to be put. There is a fair amount of remelted lead available in the United Kingdom.